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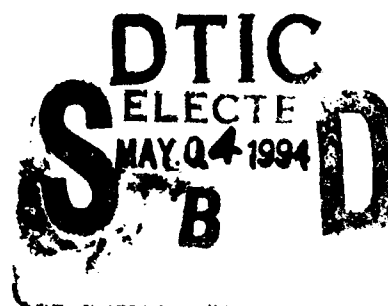
**TECHNOLOGY TRANSFER SUMMARY REPORT (FY92)  
NAVAL SURFACE WARFARE CENTER  
DAHLGREN DIVISION**

A278

BY RAMSEY D. JOHNSON

SCIENCE AND TECHNOLOGY PROGRAM OFFICE

20 APRIL 1994



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**NAVAL SURFACE WARFARE CENTER  
DAHLGREN DIVISION • WHITE OAK DETACHMENT**

Silver Spring, Maryland 20903-5640

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## FOREWORD


This report summarizes the Naval Surface Warfare Center Dahlgren Division's (NSWCDD's) participation in the following five principal areas involving technology interactions with the public and private sectors in FY92:

1. Domestic Technology Transfer (DTT)
2. Navy Potential Contractor Program (NPCP)
3. Industry Independent Research & Development (IR&D)
4. Small Business Innovation Research (SBIR)
5. Science and Technology Contracting

Technology interactions from the three major Division sites (Dahlgren, Virginia; Panama City, Florida; and White Oak, Maryland) are included herein.

Division technical staff members supporting science and technology and domestic technology transfer tasks contributed to the information presented in this report. Questions or requests for additional information should be referred to NSWCDD, Code D4T, Mr. Ramsey D. Johnson, (301) 394-1505 or DSN 290-1505.

Approved by:

  
THOMAS A. CLARE  
Executive Director

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**ABSTRACT**

**This report summarizes the Naval Surface Warfare Center Dahlgren Division's (NSWCDD's) participation in the following five principal areas involving technology interactions with the public and private sectors:**

- 1. Domestic Technology Transfer (DTT)**
- 2. Navy Potential Contractor Program (NPCP)**
- 3. Industry Independent Research & Development (IR&D)**
- 4. Small Business Innovation Research (SBIR)**
- 5. Science and Technology Contracting**

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## INTRODUCTION

The Naval Surface Warfare Center Dahlgren Division (NSWCDD) is an active participant in the following Navy and Department of Defense (DoD) programs that promote technical interactions with the private sector:

- Navy Domestic Technology Transfer (DTT)
- Navy Potential Contractor Program (NPCP)
- Industry Independent Research and Development (IR&D) Program
- Small Business Innovation Research (SBIR) Program
- Category 6.1, 6.2, and 6.3A (Science and Technology) Contracting

This report summarizes FY92 NSWCDD participation in these programs.

## DOMESTIC TECHNOLOGY TRANSFER

### BACKGROUND

For many years, the U.S. civilian sector has derived significant spinoff benefits from the Navy's efforts in the development and application of technology. In most cases, these transfer actions occurred on an ad hoc basis. Recognizing that the Nation would derive considerably greater benefits if DTT activity were encouraged and systematically pursued as a matter of policy, Congress passed legislation<sup>1</sup> to stimulate improved use of federally funded technology developments, including authority for federal laboratories to participate in Cooperative Research and Development Agreements (CRADAs) with U.S. industry and academia. To underscore this legislative interest, the President issued an Executive Order<sup>2</sup> calling for prompt action in implementing these initiatives for facilitating U.S. private sector access to federal science and technology. The DoD DTT Program was authorized<sup>3</sup> in response to the requirements of References 1 and 2.

### NAVY DTT

The Navy policy of actively promoting military-civilian DTT and associated CRADAs is promulgated by directives from the Secretary of the Navy<sup>4</sup> and the Chief of Naval Research.<sup>5</sup> In this context, DTT involves the transfer of technology developed by the Navy, including inventions, software, and training technology, to the U.S. civilian sector for use in nonmilitary applications. Of course, in carrying out this policy, due care must be taken to avoid actions that might create the appearance of undue influence over, or competition with, private enterprise and the free

operation of the economy. In addition, the policy must be carried out within the constraints of proper control of classified information, military sensitive unclassified information, and militarily critical technologies.

## NSWCDD PARTICIPATION

NSWCDD (pre-consolidation components) was participating in technology transfer activities prior to the federally enacted legislation<sup>1</sup> and was represented as a charter member of the DoD Technology Transfer Consortium in 1971. This organization has subsequently evolved into the Federal Laboratory Consortium, of which NSWCDD continues to be a contributing member.

Although NSWCDD endorses and actively pursues technology transfer activities involving Division research and development (R&D) efforts, significant and necessary limitations exist on the amount of NSWCDD-developed technology appropriate for transfer. With the work heavily oriented toward naval warfare applications, frequently no civilian application is apparent without extensive adaptive engineering effort. Security classification and export control of critical technologies are also significant constraints.

Public Law 99-502<sup>1</sup> requires that each federal laboratory either establish an Office of Research and Technology Applications (ORTA) to manage DTT activities or perform the ORTA functions within an existing organizational structure. Since NSWCDD has long maintained a DTT office, this organizational structure was unchanged following passage and implementation of Public Law 99-502. The principal elements of NSWCDD participation in DTT are described below.

## PROGRAM IMPLEMENTATION

### Management

The Division's domestic technology transfer policy is administered by the Science and Technology Program Office (Code D4T) for the Dahlgren and White Oak sites, and by Code 10P for Panama City. These offices provide policy planning and guidance on technology matters impacting the role, mission, and long-term commitments of the Division. Policy implementation vehicles for technology transfer include the Division's ORTA, the Navy Potential Contractor Program, and the Federal Laboratory Consortium for Technology Transfer. The IR&D Program is also a contributor to technology transfer activities since the transfer process can involve a two-way exchange between government and nongovernment organizations. The IR&D Program serves to inform government technologists about industry-initiated research and it also serves as a mechanism for government researchers to appraise the progress and relevance of industry-initiated efforts. Guidance regarding technology transfer constraints is provided by the Militarily Critical Technologies List (MCTL), and the Division contributes to the technical review of export license applications received by the Navy International Programs Office. Technology transfer management functions include:

- Managing the program within the Division
- Preparing Technology Application Assessments



- Maintaining external liaison (with the Office of Naval Research, the Federal Laboratory Consortium for Technology Transfer, the Department of Commerce, other federal agencies, state and local governments, universities, and private industry)
- Assisting potential user organizations in formulating their problems
- Providing and disseminating information on federally owned or originated products, processes, and services having potential application to state and local governments and private industry
- Providing technical assistance in response to requests from state and local governments
- Functioning as Division manager for MCTL matters
- Serving as Division manager for review of Navy-related export license applications

The Division manager for ORTA/Technology Transfer is Mr. Ramsey D. Johnson, Code D4T, (301) 394-1505 or DSN 290-1505 for the Dahlgren, Virginia, and White Oak, Maryland sites. At Panama City, Florida, the manager is Mr. Edward C. Linsenmeyer, Code 10P, (904) 234-4161 or DSN 436-4161.

### Technical Effort

**Project Work.** Directly attributable and quantifiable technology transfer work performed by Division technical departments is generally represented by those projects funded by other government (non-DoD) sponsors and private parties (excluding that effort funded under DoD contracts). This type of effort, identified as project work, has manpower and funding allocations that are directed towards a specific objective or requirement per sponsor request.

**Technological Disclosures.** In its role as a major government R&D center, NSWCDD also serves as a significant contributor to federal technology transfer in a more generic nature via technological disclosures in the open literature such as patents, reports, journals, and participation in symposia. The benefits from this type of activity accrete as spin-offs from DoD mission-related projects that are supported by federal R&D appropriations. Although it is less tangibly measurable than technology transfer contributions of direct project work involving end-products, the long-term benefits are more highly promising since they provide the innovative community with a broad spectrum of new stimuli to promote economic, technical, and quality-of-life growth in the private and public sectors.

### Navy-wide Services

The Division manages, edits, and publishes the "Navy Domestic Technology Transfer Fact Sheet." This monthly publication highlights Navy-wide technology and developments that have public release approval and are of potential benefit to public and private organizations, individuals, and other federal laboratories. The program is sponsored by the Office of Naval Research (Code 36) to provide a highly

visible source and focus for the dissemination of domestic technology transfer contributions from the Navy laboratory community.

## PROGRAM FUNDING

A summary of FY92 funding support for management activities and project work performed by the Center is presented below:

	<u>FY92 (\$K)</u>
1. Administrative Functions	
ORTA Management	160
Other Technology Transfer	40
Technical Publications Division	200
2. Technical Projects	
Engineering & Information Systems Department	31
Electronics Systems Department	1007
Protection Systems Department	68
Strategic Systems Department	12
Research and Technology Department	1207
Underwater Systems Department	<u>295</u>
Total	3020

## ACCOMPLISHMENTS AND CURRENT EFFORTS SUMMARY

### Project Work and Reports

Narrative summaries of NSWCDD technology transfer related projects involving FY92 effort are presented in Appendix A. The following report, which describes recent Division accomplishments, efforts, and technology transfer related resources and participation, was published for public release:

NAVSWC MP 91-805, *Technology Transfer Summary Report (FY91)*,  
Naval Surface Warfare Center.

### Cooperative Research and Development Agreements (CRADAs)

As authorized by Public Law 99-502, a CRADA is any agreement between one or more federal laboratories and one or more nonfederal parties under which the participants may provide personnel, services, facilities, equipment, or other resources toward the conduct of specified research or development efforts that are consistent with the missions of the participating federal laboratories. Also, the federal laboratories may receive funds from, but not provide funds to, nonfederal parties under a CRADA. Further, by statute, a CRADA is not a procurement contract or cooperative agreement as those terms are used in 31 U.S.C. 6303-6305, and the Federal Acquisition Regulation (FAR) and the DoD FAR Supplement are not applicable to these agreements.

## **NSWCDD/MP-93/224**

has the following four active CRADAs:

**Defense Systems:** testing of a privately developed "Acoustic Test

**Aerospace Corporation:** battle force management software

**Inc.:** software development related to supersonic airflow

**Shipbuilding, Inc.:** titanium piping systems

### **Agreement**

al Systems Station and Florida Agricultural and Mechanical  
(AU) and the Florida State University (FSU) have an agreement  
Joint Institute for Graduate Engineering Education and Research.

### **Industry Conferences**

ferences provide a forum for government laboratories to inform  
pants about significant materials, processes, innovations, or devel-  
ve promising potential for commercial application. The general  
technical presentation sessions after which government presenters  
individual follow-up discussions with interested industrial

ology 2001" – December 1991

Domestic Technology Transfer Conference" – April 1992

CDD nomination to the "1992 Federal Laboratory Consortium (FLC)  
llence in Technology Transfer" received an Award of Merit. The topic

pmment of Resonance Apparatus for Materials Evaluation

ntive to stimulate DTT, Public Law 99-502 permits government  
ire royalties or other income resulting from the licensing of Navy  
FY92, there were 66 inventions and patent disclosures by NSWCDD  
echnology transfer applications. These are listed in Appendix B.  
the number of NSWCDD patents and inventions during FY86-92 that  
al potential. Three patents have been licensed, and the Division  
ceiving a share of the royalty income.

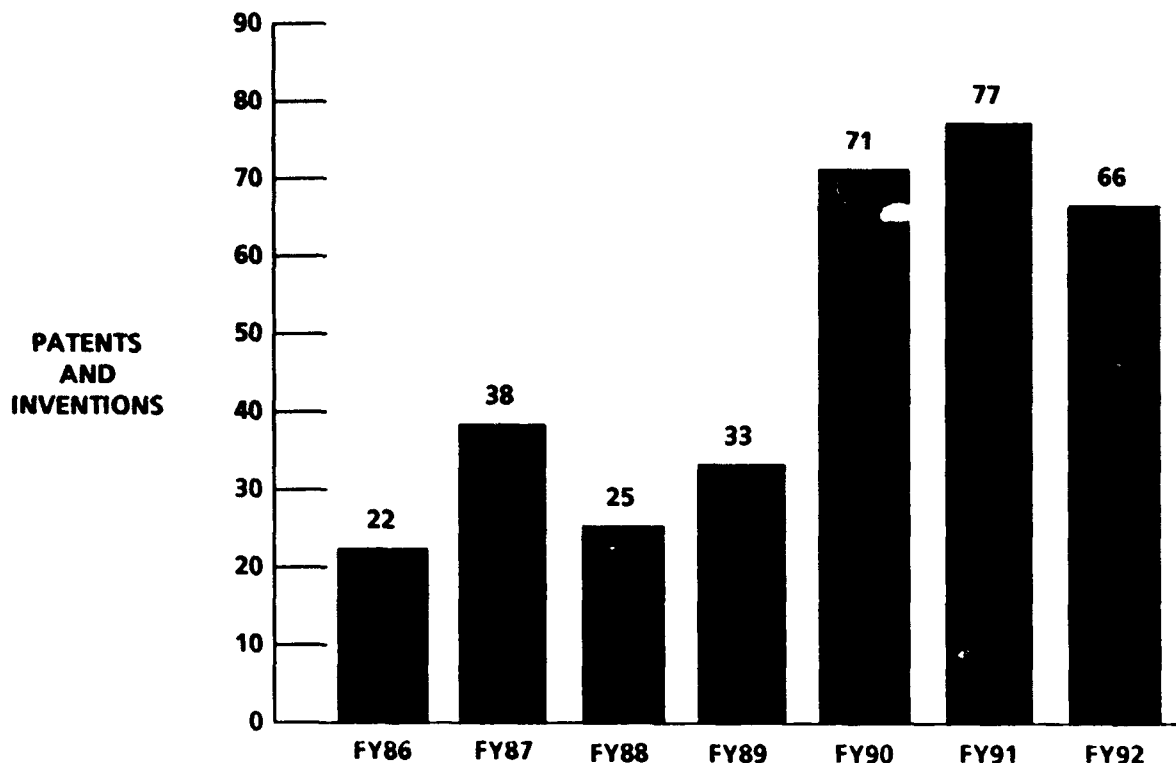


FIGURE 1. INVENTIONS AND PATENTS WITH COMMERCIAL POTENTIAL

### Navy DTT Fact Sheet

NSWCDD manages, edits, and publishes the *Navy Domestic Technology Transfer Fact Sheet*. This monthly publication highlights Navy-wide technology developments (that have been approved for public release) that are of potential benefit to public and private organizations, individuals, and other federal laboratories. The program, sponsored by the Office of Naval Research (Code ONR-36), provides a focus and a highly visible source of information for the dissemination of DTT contributions from the Navy laboratory community. All Navy laboratories are invited to contribute articles for publication in the *Fact Sheet*, which is distributed to over 11,000 subscribers across the country. NSWCDD contributed the following articles during FY89-92:

#### **FY89**

- Lightweight Nickel Composite Electrode
- Data Acquisition and Reduction Processor
- New Software Tool for Navy Development
- Electronic Security Indicating Attachment Developed
- High-energy Lithium Battery

#### **FY90**

- Method for Determining the Magnitude of Earth's Gravity Developed
- Reconfigurable M-Dimensional Computer Memory Developed

## **NSWCDD/MP-93/224**

- **Software Package to Industry**
- **New Silver Oxide (AgO) Cathode Material Developed**
- **Freezer Alarm Developed**

### **FY91**

- **Magnetoresistance Magnetometer Developed**
- **CRAM Developed**
- **Method to Identify Laser Light Sources**
- **Eyes Protected Against Laser Sources**
- **Toroidal Computer Memory Developed**
- **Measuring Resistivity Developed**
- **Kalman Filter Tracks Objects**
- **Technique to Measure Liquid Level & Volume Device**
- **Magnetic Effects Measured**
- **Device Developed to Inspect Materials**
- **"Skin Heat" Calculator Utility Program Developed**
- **Sensor for Electro-optic Voltage Developed**

### **FY92**

- **Underwater Blast Effects Data Collected**
- **NSWCDD Becomes Full Member in CSRC**
- **Mullite Whiskers & Mullite-Whisker Felt Produced**
- **"Touch" Added to New Keyboard**
- **Heat Sink for Electronic Module Packaging**
- **Ferroelectric RAM Developed**
- **Transition Radiation Interference Spectrometer Developed**
- **Pure-Cartesian Tracking Filter Developed**
- **Hot Water Storage Tank Invented**
- **Resonance Apparatus Technology Transferred**
- **Detection Circuit for Fiber-Optic Testing Invented**
- **RPV Control and Interface System Developed**

### **Technology Application Assessments**

Public Law 99-502 requires that DTT offices prepare application assessments for selected R&D projects performed by their laboratories that may have commercial applications.

A technology application assessment (TAA) is a description of a government laboratory R&D project, process, or innovative development that is cleared for public release and has potential for alternative use in the private sector. This technical disclosure is provided to the National Technical Information Service (NTIS), the National Technology Transfer Center (NTTC), and other appropriate release sources for broad dissemination in the public and private sectors. Preparation of TAAs by laboratory ORTAs is also directed by DoD 3200.12-R-4.<sup>3</sup> Figure 2 provides data on NSWCDD TAAs for FY85-92. FY92 items are presented in Appendix C and listed below:

- **Heat Sink Device**
- **Transition Radiation Interference Spectrometer**
- **A Pure-Cartesian Tracking Filter**
- **Hot Water Storage Tank**
- **Detection Circuit for Fiber-Optics Testing**

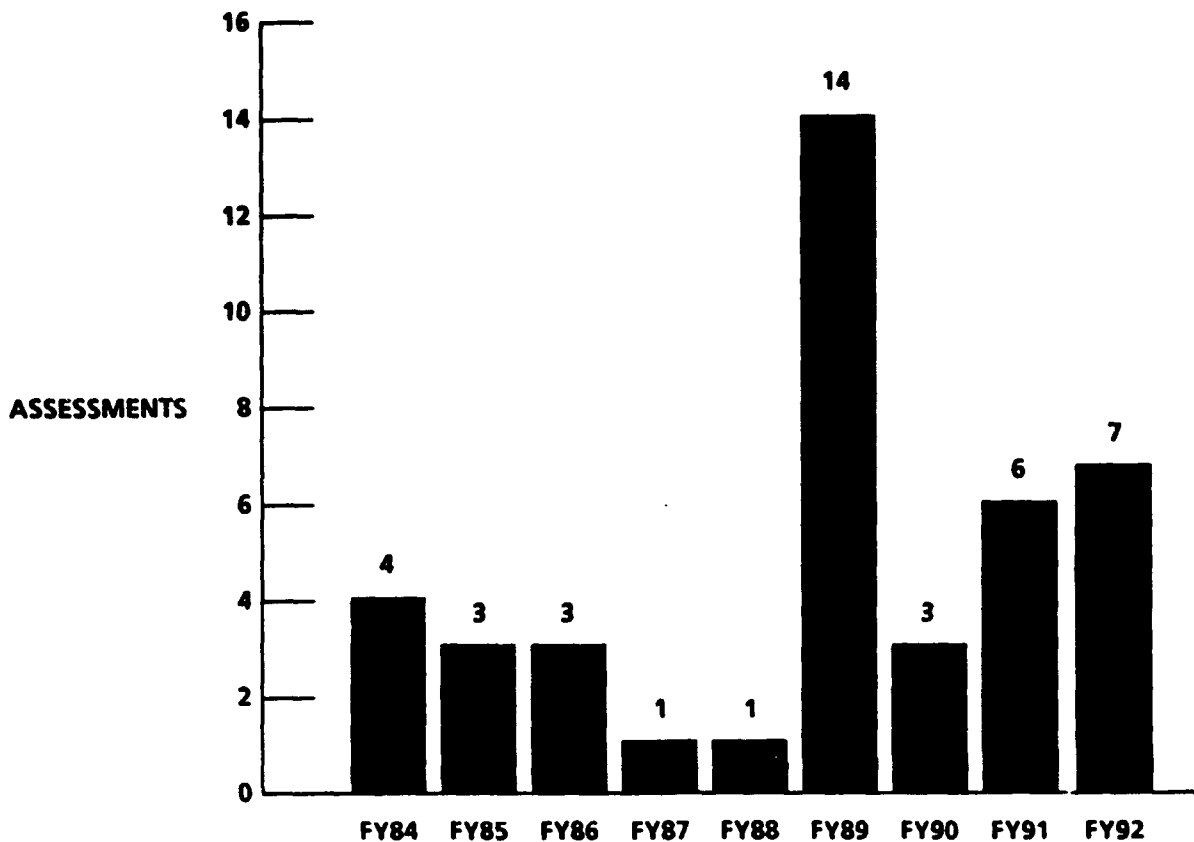


FIGURE 2. TECHNOLOGY APPLICATION ASSESSMENTS

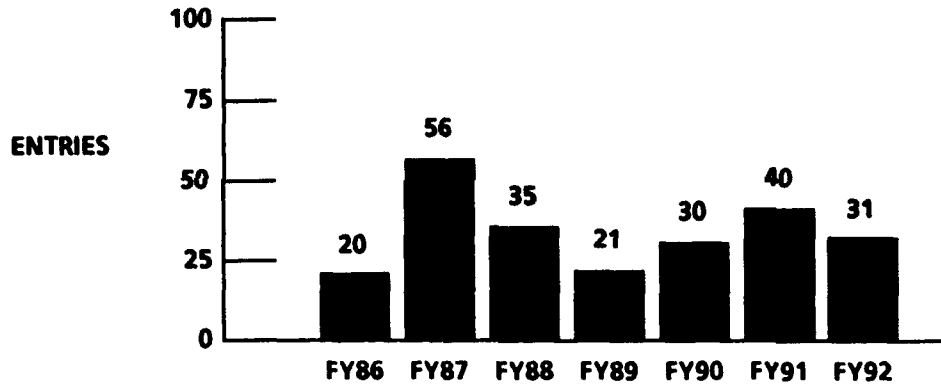
- Toroidal Computer Memory
- RPV Control and Interface System Developed

#### Other DTT Disclosures/Releases

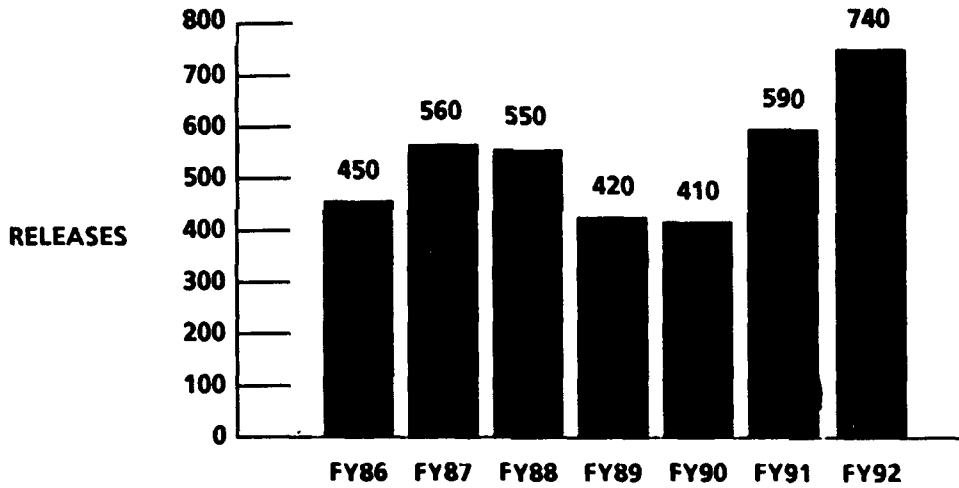
Figure 3 shows, for FY86-92, the number of NSWCDD technical publications entered in the National Technical Information Service; the number of unrestricted (public release) technical information disclosures to symposia, workshops, journals, and other publications; and the categories of responses to information requests from individuals and private industry. In FY92 the categories of responses were in the following 12 technology areas:

- Nonmetallic materials
- Electro-optics
- Software reliability analysis
- Global positioning
- Instrumentation
- Radiometry
- Batteries

**NATIONAL TECHNICAL INFORMATION SERVICE ENTRIES**



**PUBLIC RELEASES**



**CATEGORIES OF RESPONSES TO INDIVIDUALS AND INDUSTRY**

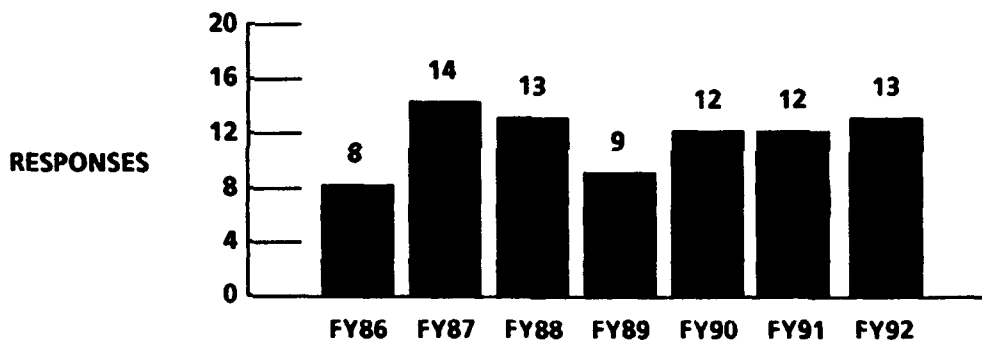


FIGURE 3. OTHER DISCLOSURES AND RELEASES

- Computer memory
- Metallurgy
- Remotely piloted vehicle control
- Human engineering (computer keyboard)
- Facilities (hydroballistics)
- Shape memory alloys

Numerous inquiries are also made directly to NSWCDD engineers and scientists in private communications; no formal records are kept of these.

#### Community Technical Outreach

NSWCDD participates in the "Science and Engineering Apprentice" and the "Bay Partners in Education" programs. These provide experience and exposure to the scientific workplace for high school students via paid apprenticeships during summer months. Division outreach includes support of nearby high schools with mentors and judges for science fairs. Division staff members also serve as volunteer math and science tutors in local elementary, middle, and high schools.

### NAVY POTENTIAL CONTRACTOR PROGRAM

If technological developments are to be applied promptly to meeting Navy requirements, it is essential that the scientific and technical community have appropriate access to technical information about those requirements.

Some requirement information is conveyed to scientists and engineers by briefings, symposia, and site visits. However, there are problems inherent to the process that may preclude information from reaching those who may be able to solve Navy technical problems. They include:

- Lack of access to information required to prepare timely and technically relevant contract proposals by qualified civilian groups that do not hold a contract
- Lack of access by holders of current contracts to classified or military critical unclassified information in areas not concerning their contracts (those data could assist them in developing alternate solutions and in planning and executing their IR&D programs)
- Lack of orientation concerning the operational environment and probable conditions in which Navy equipment must function
- Prevention of the compromise of sensitive information while ensuring that it reaches those who have a valid "need to know"



## NAVY POLICY

The Navy recognizes the need to facilitate the increased use of civilian sector technological investments in meeting military requirements. That will best be accomplished by providing civilian scientists with increased, appropriate access to defense technological data. Accordingly, the NPCP is being established to provide controlled access to relevant military data by the civilian scientific and technical sector. The NPCP will also allow use of civilian discretionary funds to address Navy needs. Navy activities are to encourage U.S. qualified firms, academia, other organizations, and individuals to participate in the NPCP. That includes U.S. firms under foreign ownership, control, or influence if the foreign interest risk is managed in accordance with the Industrial Security Regulation.<sup>6</sup>

The NPCP permits no-cost negotiated agreements that authorize access to information for specified purposes. Such agreements are not government procurement contracts, grant agreements, or cooperative agreements as defined in section 6303, 630, and 6305 of U.S.C., Title 31.<sup>7</sup> Agreements allow access to information only, and neither party is permitted to require delivery of technical goods or services as condition for NPCP participation.

## NSWCDD PARTICIPATION

Figure 4 shows the number of NPCP agreements that NSWCDD has entered into during the FY87-92 period. The agreement titles and names of the nongovernment participants for FY92 are listed in Table 1.

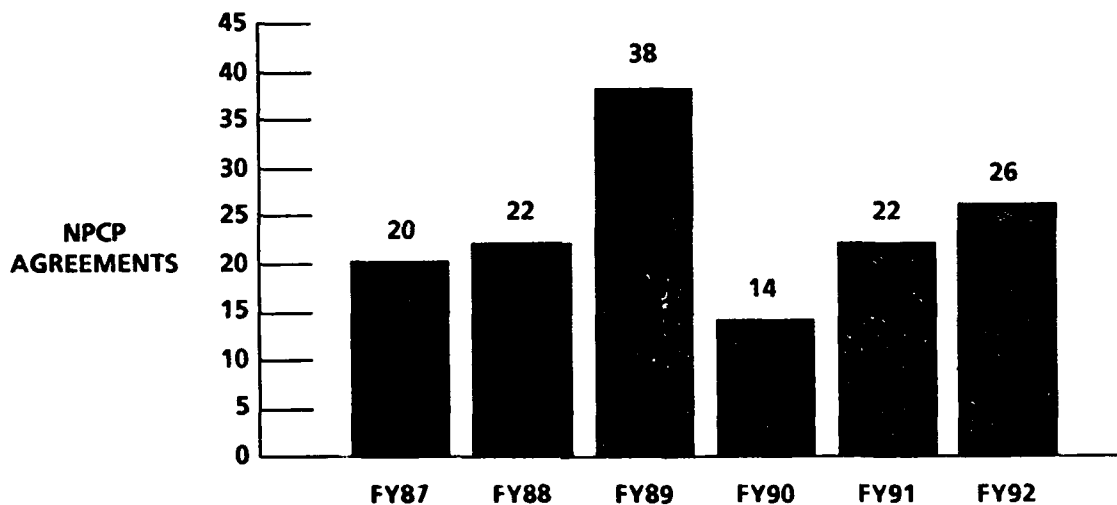


FIGURE 4. NAVY POTENTIAL CONTRACTOR PROGRAM AGREEMENTS

TABLE 1. NPCP AGREEMENTS DURING FY87-92

Company	Agreement Subject
Systems Planning Corp.	STRATPLAN 2010
Coleman Research Corp.	Short Range Antitank Weapon
LTV Aerospace & Defense Co.	STRATPLAN 2010
McDonnell Douglas Corp.	Ship Self-defense
Westinghouse Electric Corp.	Ship Electronic Warfare Systems
ITT Avionics	Surface Electronic Warfare-Ship Defense
Alliant Techsystems, Inc.	Torpedo Warhead & Fuzing Development
Raytheon Co.	Portable Magnetic Range System Concept
Southwest Research Institute	Shipboard DF Applications
MCC	Mine Detection
Alliant Techsystems, Inc.	Mine Countermeasures
ENSCO	Underwater Support
Martin Marietta/Orlando	Shallow Water Mine Countermeasures
SYSCON Corp.	Amphibious Operations
Rockwell/Anaheim	Mobile Multifunction Device
Lockheed & Missiles Space Co.	Underwater Target Recognition
Westinghouse/Oceanics	Underwater Technology
Martin Marietta Labs	Mine Countermeasures Research
Magnavox	Mine Countermeasures
Tracor	Mine Countermeasures
Dynamics Technology	Mine Countermeasures
Loral	Mobile Multifunction Device
Rocket Research	Mobile Multifunction Device
COGNITECH	Mine Countermeasures
Allied Signal	Mobile Multifunction Device
Lockheed Sanders	Nonacoustic ASW

## INDUSTRY INDEPENDENT RESEARCH AND DEVELOPMENT

IR&D is the technical effort conducted by private companies for their own business purposes; it is not sponsored by, or required in performance of, a contract or grant. In FY91, IR&D expenditures were about \$5B for research, development, and product improvement. To encourage industry to maintain a strong IR&D effort, the government allowed an average of 80 percent of this cost to be applied to overhead rates. Under present legislation, this will be an increasing percentage with total recovery scheduled for FY96.

Prior to FY92, Reference 8 required that DoD laboratories review industry IR&D projects. This included evaluation of Technical Plan submittals as well as scoring projects at On-site Reviews hosted by participating companies. Effective in FY92, Reference 9 eliminated technical evaluation of IR&D projects for rating purposes and encouraged a continuing, less formalized exchange of technical information between DoD laboratories and industry. These technical interactions are important in maintaining awareness of the quality of IR&D projects as well as determining applicability to current and future Navy and Marine Corps needs.

## SMALL BUSINESS INNOVATION RESEARCH

### BACKGROUND

The SBIR program is mandated by Public Law.<sup>10,11</sup> The basic design of the DoD SBIR program is in accordance with the Small Business Administration (SBA) SBIR Policy Directive of June 1988. DoD components invite small business firms to submit proposals under an annual solicitation entitled SBIR. Firms with strong R&D capabilities in science or engineering in any of the topic areas presented are encouraged to participate. Subject to availability of funds, DoD components will support high-quality research or R&D proposals of innovative concepts to solve the listed defense-related scientific or engineering problems.

Objectives of the DoD SBIR program include stimulating technological innovation in the private sector, strengthening the role of small business in meeting DoD R&D needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research or R&D results. Recent NSWCDD SBIR participation is summarized in Figure 5.

The annual DoD program solicitation strives to encourage scientific and technical innovation in areas specifically identified by DoD components. Guidance incorporates and exploits the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD.

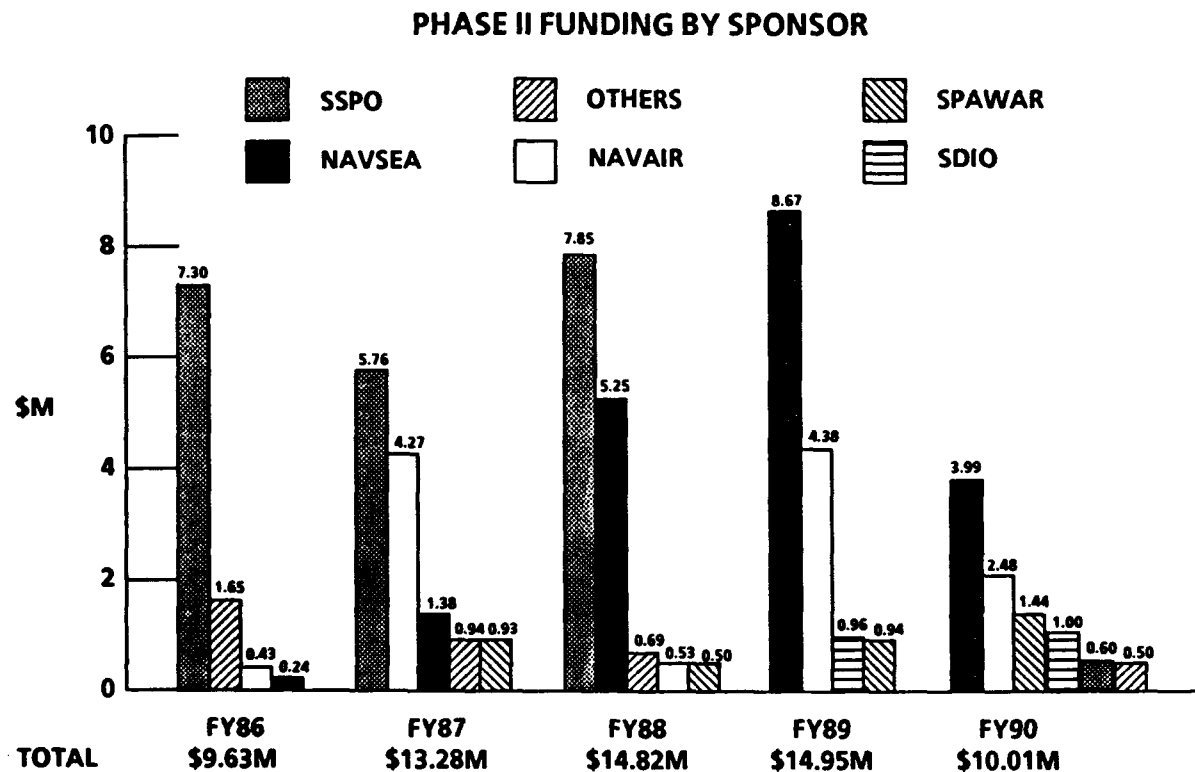
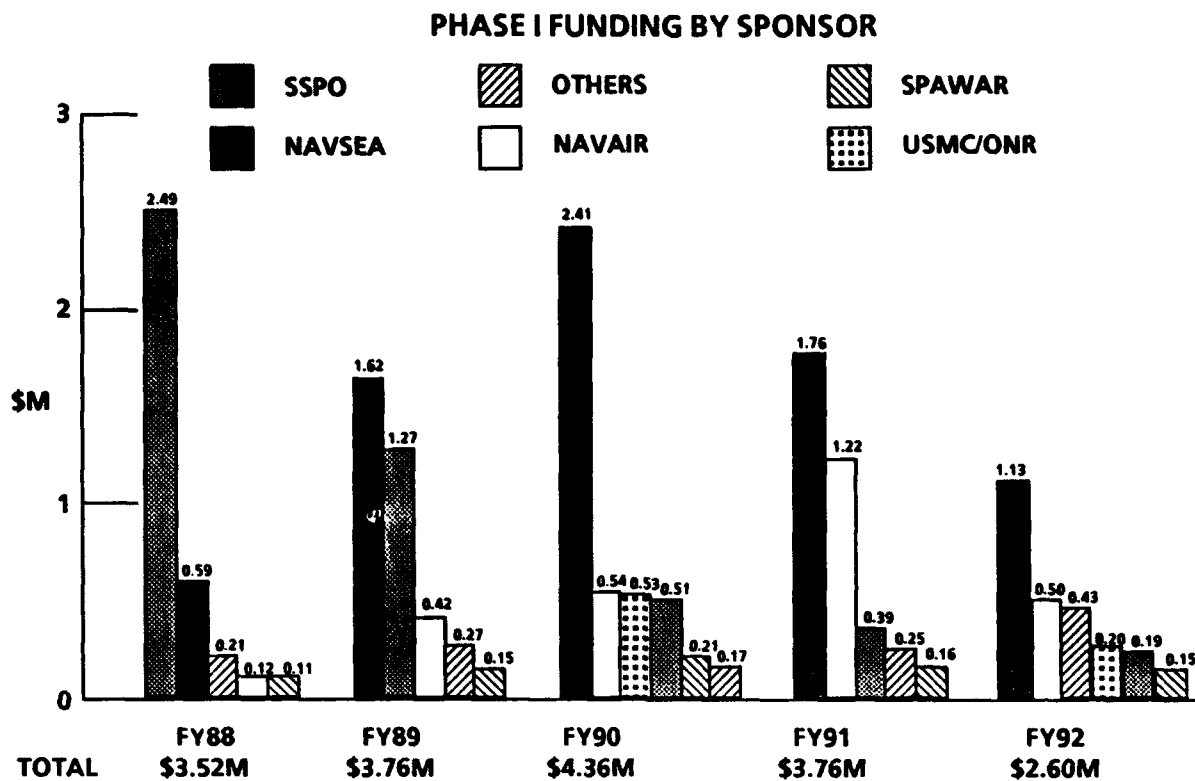


FIGURE 5. SMALL BUSINESS INNOVATION RESEARCH

### THREE-PHASE PROGRAM

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR program. Typically, it involves about half a man-year of effort over a period of 6 months or less. Proposals should concentrate on efforts that will significantly contribute to establishing the feasibility of the proposed effort. Successful completion of those efforts is a prerequisite for further DoD support in Phase II.

Phase II awards will be made to firms only on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal. Phase II awards will typically cover 2 to 5 man-years of effort over a period generally not to exceed 24 months, subject to negotiation. Phase II is the principal research or R&D effort and is expected to produce a well-defined deliverable product or process. A more comprehensive proposal is required for Phase II.

Under Phase III, nonfederal capital is expected to be used by the small business to pursue commercial applications of the research or development. Under Phase III, federal agencies may also award non-SBIR-funded follow-on contracts for products or processes that meet the mission needs of those agencies. The solicitation is designed in part to provide incentives for the conversion of federally sponsored R&D innovation in the private sector. The federal R&D can serve as both a technical and preventure capital base for ideas that may have commercial potential.

### SCIENCE AND TECHNOLOGY CONTRACTING

In addition to the cooperative efforts with industry described above, NSWCDD participates even more directly, in a major way, with industry by contracting out roughly half of its total science and technology funding. Through these mutually beneficial contracts, the Navy is able to apply the talents and facilities of industry to the achievement of its technology objectives.

Science and technology funding consists of the following Category 6 funding appropriations:

- 6.1: Research
- 6.2: Exploratory Development
- 6.3A: Advanced Technology Development

Figure 6 shows a breakout of NSWCDD in-house and contracted science and technology funding for FY89-92 expenditures.

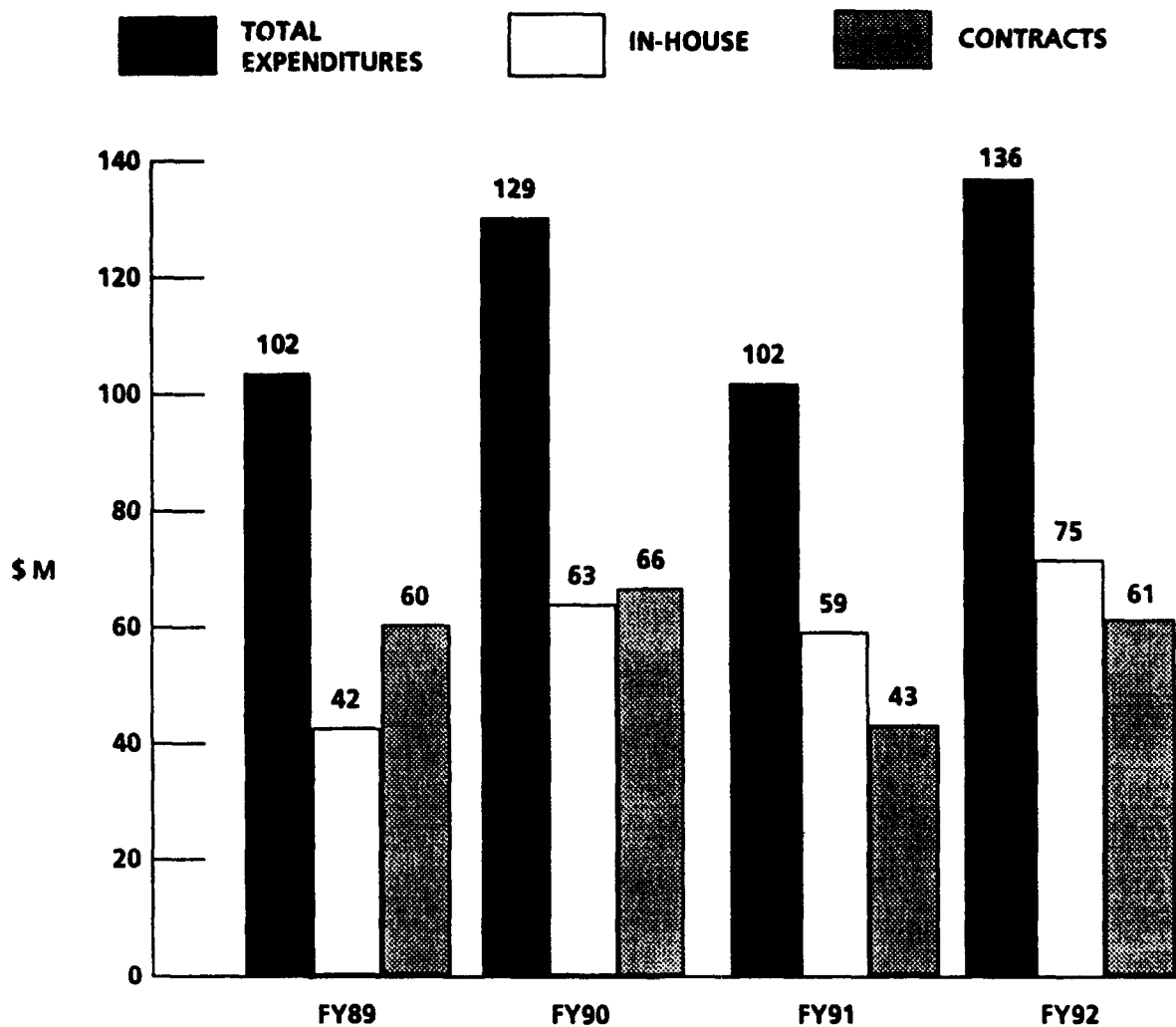


FIGURE 6. SCIENCE AND TECHNOLOGY EXPENDITURES

## REFERENCES

1. Public Law 96-480, "Stevenson-Wydler Technology Innovation Act of 1980," 21 October 1980, as amended by Public Law 99-502, "Federal Technology Transfer Act of 1986," 20 Oct 1986.
2. Executive Order 12591, "Facilitating Access to Science and Technology," 10 Apr 1987.
3. DoD 3200.12-R-4, "Domestic Technology Transfer Program Regulation," 27 Dec 1988.
4. SECNAVINST 5700.16, "Domestic Technology Transfer."
5. OCNRINST 5700.1, "Navy Domestic Technology Transfer Program."
6. DoD 5220.22-R of Dec 1985, "Industrial Security Regulation."
7. U.S.C., Title 31, "Money & Finance: Treasury."
8. Public Law 91-441, "DoD Appropriations Authorization Act, 1971."
9. Public Law 102-190, "National Defense Authorization Act for Fiscal Years 1992 and 1993."
10. Public Law 97-219, "Small Business Innovation Development Act of 1982."
11. Public Law 99-443, "Small Business Innovation Research Program Extension."

**APPENDIX A**

**NARRATIVE SUMMARIES FOR NSWCDD FY92 TECHNOLOGY  
TRANSFER RELATED PROJECTS**



## MANUFACTURING TECHNOLOGY

The Navy Manufacturing Technology Program requires that technology transfer to the private sector and government agencies be a major activity of each funded project. Accordingly, upon completion each project is required to have an end-of-project demonstration for potential users or vendors and to issue a final report. In both instances, efforts are made to disseminate the information to the widest possible audience. However, while some of the information is classified and some is unclassified, all is associated with critical, sensitive technologies. This information is not releasable for public information and such requests are individually assessed based on distribution restrictions. Each project manager is encouraged to actively communicate with interested parties during the project to transfer the developing technology.

In addition to technical project work, the Naval Surface Warfare Center Dahlgren Division (NSWCDD) also provides, upon request, technical and administrative program support to the Office of Naval Acquisition Support; the Naval Sea Systems Command; and the Office of the Assistant Secretary of the Navy, Shipbuilding and Logistics (OASN, S&L) for manufacturing technology programs.

The following Manufacturing Technology projects are active at NSWCDD:

- Cast Projectile Program
- Spin Form Discontinuous Metal Matrix Composites (MMCs)
- Composites for Passive Thermal Management

## SPACE SHUTTLE STUDY

NSWCDD has been supporting the National Aeronautics and Space Administration's (NASA's) Marshall Space Flight Center and the Air Force 45th Space Wing (45SPW) continually since 1987 with Space Shuttle Range Safety studies. In FY92, two significant events occurred.

First, NSWCDD provided NASA and 45SPW with the full justification and convincing technical rationale for full and permanent removal of the liquid hydrogen (LH<sub>2</sub>) tank range safety system (RSS). NASA had been pursuing the removal of the external tank RSS from the Space Transportation System since the 1970s when the Space Shuttle was still under development. The removal of the LH<sub>2</sub> RSS resulted in significantly improved safety and a cost savings of approximately \$100,000 per launch.

The second area of support in FY92 was initiating a new study to analyze the breakup of the advanced solid rocket booster (ASRB) from a range safety destruct action. The ASRB is under development to eventually replace the currently flown redesigned solid rocket booster (RSRB). The ASRB will provide more lift capability than the RSRB and poses a potentially greater range safety hazard due to the increased amount of propellant. Certain features of the ASRB design, however, may actually help increase the degree of propellant breakup which could result in a net decrease in hazards in comparison with the RSRB.

## SPACE SHUTTLE PAYLOAD EXPERIMENT

Space shuttle mission STS-46 launched in July 1992 involved a retrievable experiments platform that would be recovered during another shuttle flight in 1993. One of the payloads on this platform was a set of NSWCDD materials test samples to be exposed to the space environment. The samples included carbide, oxide, and phosphate coatings being developed to protect space structural and thermal management components from the atomic oxygen present in low earth orbits, structural carbon-carbon composite material, and a space mirror made of foam metal matrix composite. The samples have been returned from the orbital exposure and are being analyzed to determine the degree of reactivity with the space environment.

## NASA/MARSHALL SPACE FLIGHT CENTER SUPPORT

1. Solid Propellant Initiative Program (SPIP) support. Conduct an advanced nozzle cements and adhesives study to assist NASA in determining those commercially available rocket nozzle cements best suited for bonding various parts of rocket nozzles such that they will survive the intended mission. Major tasks of the study are to determine the bond strength and characteristic yield of the cement after its major decomposition together with its gas evolution.

- Presented and published the results of the chemical and thermal characterization of VCAR C-34 and Dylon GC cements.
- Curing kinetic studies were published on VCAR C-34, Dylon GC, and an advanced cement, C-90, provided by the Union Carbide Corporation.
- A new advanced cement consisting of a 1:1 blend of an ethynyl terminated aspartimide (ETA) and an ethynyl terminated arylene ether (ETA-E) oligomer was prepared and characterized.

2. Carbon-carbon Manufacturing Process. Investigate the applicability of using the eddy current nondestructive test technique to evaluate carbon-carbon composite materials throughout the manufacturing process.

- Flexible probes were manufactured and were used to scan curved carbon-phenolic material specimens.

3. Ultrasonic Assessment of Large Solid Rocket Motor Bondline Integrity. Determine the integrity of bondlines in large solid rocket motors using Time Delay Spectroscopy (TDS).

- Obtained TDS equipment and compared its inspection performance with conventional tone burst techniques on several simulated motor sections and with laboratory specimens. Noted over 30 dB signal-to-noise improvement.
- Presented results and disclosed technique at appropriate meetings.
- Measured ultrasonic velocity and attenuation of simulated propellants.

- The feasibility of using air-coupled ultrasonics to detect defects in large solid rocket motor segments was demonstrated.
- The acoustic emission technique was used to indicate initiation of damage within solid propellant grains when subjected to tensile stresses.
- Provided NASA/Marshall program management with an independent assessment of the technical aspects of the program related to nondestructive testing.

4. **Characterization of Bondline Mechanical Performance.** Support NASA in developing a methodology for accurate and reliable characterization of bondline performance via chemical and mechanical testing and analysis of bondline specimens.

- Conduct experiments to characterize bondlines in terms of constituents, bond-in-tension specimen testing, and dewetting parameters.
- Continue efforts on constitutive model development and conduct chemistry studies of gradient properties at or near bondlines, along with combustion studies of strained propellant specimens in the bondline region.
- Work with the Structures and Mechanical Behavior Subcommittee (S&MBS) of JANMAF and represent NASA SPIP in the development of bondline test specimen standards.

## NIGHT VISION EQUIPMENT

In support of the U.S. Border Patrol (USBP) of the Immigration and Naturalization Service, NSWCDD provided technical assistance and expertise for the repair and upgrade of night vision equipment owned by the USBP. This equipment is used by the USBP in the protection of U.S. land and water boundaries against illegal entry of aliens, drugs, and other contraband.

## TEST FACILITIES

NSWCDD's Ft. Lauderdale Test Facility established a test site for advanced underwater sensors and platforms as part of a commercially sponsored collaborative project. Teams from the Ft. Lauderdale Facility, the Harbor Branch Oceanographic Institution, and Raytheon Company successfully deployed and tested selected equipment at this new site.

## COUNTER-NARCOTICS SUPPORT

Under Coast Guard sponsorship, NSWCDD evaluated the feasibility of using the Navy's Search and Surveillance Planning System (SSPS) to support the interdiction of drug traffickers. Results demonstrated that SSPS has direct value to both tactical and strategic allocation of search and surveillance forces supporting the

counter-narcotics mission. SSPS capabilities are very complementary to the requirements for counter-narcotics search and surveillance planning.

## **X-RAY SOURCE**

By means of a Technical Support Agreement with a Small Business Innovation Research (SBIR) contractor, NSWCDD participates in a program to investigate the use of parametric X-ray radiation (PXR) as a low-cost, pulsed, tunable X-ray source. PXR generation is achieved by placing natural or synthetic crystals, or multilayer structures into a relativistic electron beam. Potential commercial applications of this technology include use as an X-ray source for medical imaging of heart arteries and as an X-ray lithography source for the production of microintegrated circuits.

## **DEPARTMENT OF TRANSPORTATION (COAST GUARD) SUPPORT**

1. NSWCDD was tasked to produce a Personnel Qualifications Standard (PQS) which provides electromagnetic countermeasures/electromagnetic interference (EMC/EMI) awareness for use by United States Coast Guard personnel having responsibility for maintenance and repair of various configurations of Identification Friend or Foe (IFF) equipment/systems. The PQS, intended for use as a complement to formal IFF training, will include necessary information and guidance for technicians to identify EMC/EMI problem areas and instill the knowledge necessary to maintain IFF systems/equipments in optimum operational condition.

2. The following weapons system safety support was provided for the Hamilton class and Bear class Coast Guard cutters:

- Design of firing cut-out zones for the Mk 75 and CIWS weapons
- Fabrication of cut-out cams
- Verification and certification of safe firing zones

## **FAA BLAST LOADING PROGRAM**

After the Pan Am 103 bombing, the Federal Aviation Administration (FAA) undertook a program to develop hardening techniques for commercial aircraft. As a part of this effort, the Explosion Dynamics Branch was tasked to provide the blast loads produced by small explosions (explosive weight less than 3 pounds) inside suitcases. A series of tests was conducted with explosive weights of 1.5 and 3.0 pounds. The test included the effects of multiple suitcases – up to a series of final tests with 80 suitcases inside an LD3 baggage container. The data form a predictive data base. In addition, the data were used to validate the computer code INBLAST, which can now be used to make the loading predictions.

## **ARGONNE NATIONAL LABORATORY**

The Argonne National Laboratory and NSWCDD collaborated in the development/adaptation of charged-particle beam diagnostics for the Advanced Photon Source Project. The principal thrust involved interaction mechanism such as optical transition radiation (OTR) and synchrotron radiation (SR) that convert information about the electron or positron beams into photon sources that then can be

imaged. Supplementary work may address X-ray diagnostics, Smith-Purcell Effect, undulator radiation, and photon beam transport.

## BUREAU OF ENGRAVING AND PRINTING

Per Bureau of Engraving and Printing (BEP) specifications, NSWCDD fabricated Copepak cassette plates and printing sleeves for the Hamilton web currency press. Computer numerically controlled (CNC) capabilities offered substantial time and cost savings to BEP.

## SHOCK AND VIBRATION ANALYSIS CENTER

The Shock and Vibration Information Analysis Center (SAVIAC) is an interagency effort chartered to provide a clearinghouse to analyze and exchange technical information in the technical specialty area of shock and vibration. Oversight of SAVIAC is provided by an interagency Technical Advisory Group (TAG) that was initially chaired by NSWCDD. Members from the Army, the Air Force, the Navy, the Defense Nuclear Agency, the Department of Energy, and NASA comprise the TAG. This cooperative effort at information collection, distribution, analysis, and exchange is an important tool in addressing survivability and protection issues and problems encountered in operational environments. SAVIAC can be used by any of the sponsoring agencies and their contractors. It is on-line to provide special analysis and technical evaluation studies for specific problems raised in research and development (R&D) programs and other efforts.

## TOURMALINE GAUGES

The original tourmaline gauge was designed and developed under Navy contract at Woods Hole Oceanographic Institute during World War II. These gauges are used to measure shockwave phenomena from underwater explosions. After the war, scientists formed Crystal Research Company to market the gauge; the company closed in 1972. NSWCDD purchased the company assets and began producing gauges to fill the void left by the defunct company. Improvements have been made to the gauges in relation to evolving technology.

NSWCDD constructs and calibrates the gauges, which are sold at fixed price to various Government and industry research activities. Gauges and related information are exchanged with foreign governments with whom the U. S. has information exchange agreements. The following have purchased gauges in FY92:

- M. G. Associates/New Jersey
- Dyno Westfarmer Ltd./Australia

## CASE TECHNOLOGY FOR THE FAA

Computer Aided Software Engineering (CASE) technology is being applied to develop models in support of the FAA's system-wide architecture for integrating its software applications to achieve more efficient management operations and data sharing functions. The initial effort addresses the development

of models which analyze the organizational structure of the Office of Information Technology.

#### **NASA/LANGLEY RESEARCH CENTER SUPPORT**

In FY92, NSWCDD continued a detonator cord study for the NASA Langley Research Center to determine what effect, if any, accelerated thermal aging has on the "swage area" of 21/2 grains per foot shielded mild detonating cord (SMDC) containing DIPAM and HNS as the energetic core materials. This information was necessary to support an Air Force decision regarding the necessity of funding a comprehensive study to begin in 1993.

#### **DEPARTMENT OF TRANSPORTATION/FHWA**

1. Under previous Federal Highway Administration (FHWA) sponsorship, NSWCDD has developed a prototype battery-operated motor vehicle detection system. This Self-Powered Vehicle Detector (SPVD) may be buried in any type of road surface and uses radio frequency (RF) transition rather than hardwiring for communication with its control unit. The detector reads a vehicle's magnetic signature, processes it, and transmits the vehicle's presence to the remotely located control unit. Details of this device are provided in NSWCDD Technology Application Assessment NSWC-TAA-85-002.

2. In FY92, NSWCDD provided design consultation and testing for preproduction SPVD units being manufactured by private industry under FHWA contract.

#### **ELECTROMAGNETIC RADIATION SAFETY**

NSWCDD performs Hazards of Electromagnetic Radiation to Ordnance (HERO) analyses and surveys for various non-DoD agencies such as the National Oceanographic and Atmospheric Administration; the National Weather Service; and the Departments of State, Commerce, and Transportation. This work supports safety considerations regarding specific design and locations of radar and radio transmitter sites at existing facilities and new construction locations.

#### **LASER WELDING FOR ROCKET MOTORS**

NSWCDD and a private company participated in a study in FY90 to investigate a laser welding manufacturing procedure for steel rocket motor cases (RMCs). The principal test parameter was to hold the back wall temperature to less than 250°F (for potential live RMC applications). Laser parameters were developed and the technique was applied to steel RMC cylinders (mock-ups) and an all-up RMC simulator that was ablatively lined. Initial tests met the temperature requirement, but the organic ablative/adhesive appeared to contaminate the weld of the ablatively lined case. Reporting was completed in FY92.

**SYSTEMS RESEARCH CENTER AT VIRGINIA POLYTECHNIC INSTITUTE  
AND STATE UNIVERSITY (VPI&SU)**

In 1983, NSWCDD, the Naval Sea Systems Command (NAVSEA), Combat Systems Directorate (SEA-06), and VPI&SU established the Systems Research Center (SRC) at the University. The SRC is intended to augment the technology base of NSWCDD in serving the R&D needs of surface combat systems, recognizing that the benefits derived can extend to subsurface and air platforms as well. The SRC has also expanded the technology base for other U. S. Navy R&D activities serving R&D needs of surface combat systems. The SRC, NSWCDD, and NAVSEA's (SEA-06) joint effort emphasizes computer science and computing technology, key elements in modern naval applications. The SRC was established to perform only R&D.

By the close of FY89, the SRC had received nearly \$4.52 million to perform 41 separate tasks. In FY89, there were 10 active tasks with the SRC. Of these, 5 began in FY88 and 5 in FY89. Of the 10 projects, NSWCDD sponsored 9 at a cost of over \$764K.

In late September 1989, an Indefinite Delivery Indefinite Quantity (IDIQ) contract was signed with VPI. The contract calls for performance from 30 September 1989 through 30 September 1994. An extension of no less than two years is under consideration. The IDIQ contract has a potential value of nearly \$7.78 million if fully funded. As of January 1992, 21 delivery orders valued at \$1,713,210 have been initiated under the IDIQ.

**COMPUTER SCIENCE RESOURCES CONSORTIUM**

The Computer Science Department at VPI&SU has established a Computer Science Resources Consortium (CSRC) program with the goal to strengthen existing interactions and to create new interactions between VPI&SU professors, the government, and the industry technical community. NSWCDD has been an associate member of this Consortium since 1984 and has provided a representative for the CSRC Steering Committee during that time. NSWCDD became a full member in 1990.

Mutual benefits of the program include the following:

- Provides a resource of quality graduates to academia, industry, and government.
- Promotes government/academia personnel exchanges.
- Provides feedback for orienting teaching requirements toward real-life applications.
- Provides an increased awareness of outside requirements to focus academic research efforts.

The Consortium sponsored the following events that promoted technology transfers:

- A semiannual newsletter featuring articles on current research activities.

- A yearly catalog of technical reports from the VPI&SU Computer Science Department.
- A yearly publication "Great Companies to Work For," profiling the CSRC members.
- A yearly "Student Profile Catalog," containing resumes of undergraduate and graduate students.
- The Annual Virginia Computer Users Conference combined with the Annual CSRC Steering Committee meeting



**APPENDIX B  
NSWCDD FY92 INVENTIONS AND PATENTS  
WITH COMMERCIAL POTENTIAL**

## APPENDIX B

## NSWCDD FY92 INVENTIONS AND PATENTS WITH COMMERCIAL POTENTIAL

Technological Area	Navy Case or Patent No.	Title and Purpose	Potential Commercial Applications
Communication Equipment	5,054,758	Multi-PLY Paper Separator	Multi-copy computer printers
Electronics	5,060,115	Heat Sink Device for Electronics Modules Packaged in Cylindrical Casings	Aircraft maintenance and other applications where the environment must be spark free
Power Generation	5,059,839	Explosive Magnetic Field Compression Generator Transformer Power Supply for High Resistive Loads	Power generation equipment
Aerospace	5,071,087	Method of Guiding an In-flight Vehicle to a Desired Flight Path	Aerospace air control
Quality Control	5,073,720	Liquid Level and Volume Measurement Device	Medical and quality control laboratories where measurement of liquid must be accurate and quality control is important
Solar Systems	NC# 73,767	Hot Water Storage Tank for Solar Collectors	Solar heating systems
Computer Hardware	NC# 73,749	I/O Interface Between VME Bus and Asynchronous Serial Data Computer	Computer hardware
Electronics	NC# 74,029	Translating Wedge Heat Sink	Instrumentation buoys, underwater cable, amplifiers, manned or unmanned submersible vehicles
Fiber-optics	NC# 74,156	Fiber-Optic Testing System Having a Detection Circuit	Fiber-optic component test equipment. Analog optical signal sensing, fiber optic sensors.
Air Traffic Control	NC# 73,773	Two-stage Target Tracking System and Method	Future air traffic control system

## APPENDIX B

## NSWCDD FY92 INVENTIONS AND PATENTS WITH COMMERCIAL POTENTIAL (CONTINUED)

Technological Area	Navy Case or Patent No.	Title and Purpose	Potential Commercial Applications
Radars, Transmitters	NC# 74,240	High Performance Pulse Generator	Commercial radars, transmitters, etc.
Charged Particle	5,120,968	Emittance Measuring Device for Charged Particle Beams	All accelerator based charged particle beam technologies
RF Energy	NC# 74,457	Radio Frequency Cable to Optical Fiber Cable Converter Interface	Wherever RF energy is used.
Optics	5,134,361	Optical System for Linearizing Non-linear Electro-optic and Magneto-optic Effects	Optical systems
Computers	5,134,508	Optical High-speed Parallel Backplane	Computers and control systems
Image Transmission, Satellite Mapping	NC# 74,126	Self-organizing Neural Network for Classifying Pattern Signatures with "A Posteriori" Conditional Class Probability	Video image transmission equipment, satellite mapping
Optics	NC #74,500	System for Solving Boolean Equations Using Optical Lookup Tables	Optical computing
Remote Control	NC# 74,060	Remotely Piloted Vehicle Control and Interface System	Wherever a computer interfaces with R/C device to eliminate human controller
Aviation	NC# 74,059	Variable-Cycle Storable Reactants	Hypersonic aviation
Fiber-optics	NC# 73,659	Infrared Fiber-optic Temperature Sensor	Use in thermal testing of materials, thermal monitoring of avionics and power plants, perhaps used in nuclear generating plants
Computers	NC# 74,869	Reconfigurable N-Dimensional Computer Memory	Broad application in computer memory applications
EMF Shielding	NC# 73,961	Mechanical Shielding for Electric Primer	Blasting caps

## APPENDIX B

## NSWCDD FY92 INVENTIONS AND PATENTS WITH COMMERCIAL POTENTIAL (CONTINUED)

Technological Area	Navy Case or Patent No.	Title and Purpose	Potential Commercial Applications
Metal/Ceramic Composites	NC# 74,250	Silver Lined Ceramic Vessels and Method of Preparation	Reaction vessels
Metallurgy	NC# 74,170	Method of Bonding Molybdenum to Steel	High temperature steel structures
Superconductors	NC# 73,817	Multifilamentary Superconducting Cable	Superconducting cables
Superconductors	NC# 73,098	Continuous Process for Synthesis of High Temperature Superconducting Yarns and Wires	Superconducting wires and cables
Composites	NC# 72,843	Techniques for Preparation of Ingot Metallurgical Discontinuous Composites	Structural composite materials
Superconductors	NC# 73,923	Method of Producing High Temperature Superconducting Wires	Superconductor wires
Explosives	NC# 73,770	Dynamic Compaction Processing System	Compaction of graphite into diamonds
Computer Optics	NC# 73,885	Optical Pattern Recognition System Utilizing Resonator Array	Optical fiber type data processors
Laser Radiation	NC# 73,886	Tunable Laser Frequency Stabilizing System	Laser Generators
Analysis of Living Tissue Activity	NC# 74,394	Real Time Cardiac Arrhythmia Stabilizing System	Diagnosis of cardiac arrhythmia and pacemakers
Solid State Electronics	NC# 74,014	Nonvolatile Ferroelectric Memory Cell	Computer Chips
Torpedo Propulsion	NC# 74,083	Improved Thrust Expansion Engine	Underwater propulsion engines
Measurement of Plastic Cure	NC# 74,533	Non-Contacting Probe for Dielectric Cure Monitoring	Instrumentation for monitoring polymeric resins in aerospace structures

## APPENDIX B

## NSWCDD FY92 INVENTIONS AND PATENTS WITH COMMERCIAL POTENTIAL (CONTINUED)

Technological Area	Navy Case or Patent No.	Title and Purpose	Potential Commercial Applications
Doppler Radar	NC# 74,057	Target Motion Detecting Impulse Doppler Radar System	Commercial aviation radar systems
Material Stress	NC# 73,415	Magnetic Multilayer Strain Gauge	Solid state strain gauge equipment
Underwater Mine Mooring Cable	5,120,024	Payout Tension Control System for Reel Mounted Cable - prevents cable damage by excessive loading	Cable storage reels
Projectile Launching	5,131,328	Safety and Arming System for Tube Launched Projectile	Rockets or missiles
Optical and Sound Radiation	5,161,125	Radiation Selective System for Target Range and Imaging Readout	Tracking of underwater targets
Ceramic/Metal Composites	5,120,575	Silver Lined Ceramic Vessel & Method of Preparation	Reaction vessels for making high temperature superconducting ceramics and other materials
Explosives	5,149,911	Flexible Sheet Explosive	Demolition, metal cladding processes
Superconductors	5,091,362	Silver Method for Producing Coated Superconducting Ceramic Powder	Producing high temperature superconducting materials capable of being forged, swaged, drawn, etc., into wires, cables, or other structures
Carbon-carbon and Metal Matrix Composites	5,100,049	Method of Bonding Carbon-Carbon and Metal Matrix Composite Structures	Joining carbon-carbon composite and metal matrix composite pieces by diffusion bonding
Electronic Radiant Energy Generation	5,132,586	Microchannel Electron Source	(TV type) Cathode ray tubes and microwave tubes for radar systems, etc. - wide variety of electronic installations

## APPENDIX B

## NSWCDD FY92 INVENTIONS AND PATENTS WITH COMMERCIAL POTENTIAL (CONTINUED)

Technological Area	Navy Case or Patent No.	Title and Purpose	Potential Commercial Applications
Radar	5,095,312	Impulse Transmitter and Quantum Detection Radar System	Radar monitoring systems in general
Electronic Optical Tracking	5,151,746	Optical Tracking of Charged Particle Beams	Measurement of atmospheric emissions for pollution control
3-D imaging	5,110,203	Three Dimensional Range Imaging System	3-D Photography
Booster Rockets	5,117,758	Booster Rocket Range Safety System	Space Propulsion
Data Processing Hardware	5,130,890	Cable Connector/Adapter Support for Multi-Terminal Data Processors	Multi-cable computer installations
Diamond Structures	5,080,752	Consolidation of Diamond Packed Powders	Method of producing radomes or other complex shaped diamond structures
Production of Hydrogen Gas	5,143,047	Material and Method for Fast Generation of Hydrogen Gas and Steam	Rapid generation of hydrogen gas
Signal Data Processing	5,088,327	Phase Cancellation Enhancement of Ultrasonic Evaluation of Metal-to-Elastomer Bonding	Possible potential for quality control manufacturing
Space; Ordnance	5,052,272	Launching Projectiles with Hydrogen Gas Generated from Aluminum Fuel Powder/Water Reactions	To provide initial acceleration to projectiles in electromagnetic guns and launchers; rapid generation of hydrogen gas
Radiation Detectors	5,061,973	Semiconductor Heterojunction Device with Graded Bangap	Commercial potential limited to infrared detectors
Infrared Detection	5,059,786	Multi-color Coincident Infrared Detector	Possible potential for space exploration equipment

## APPENDIX B

## NSWCDD FY92 INVENTIONS AND PATENTS WITH COMMERCIAL POTENTIAL (CONTINUED)

Technological Area	Navy Case or Patent No.	Title and Purpose	Potential Commercial Applications
Superconductors	5,082,826	Silver Coated Superconducting Ceramic Powder	As a material for producing high temperature superconducting structures
Batteries	5,151,262	Pyrite Cathode Material for a Thermal Battery	Synthetic cathode material for molten salt batteries
Ceramic/Metal Composites	5,145,506	Method of Bonding Metal Carbides in Non-Magnetic Alloy Matrix	Composite structural materials
Removing Hazardous Chemicals from a Surface by Applying and Removing a Treated Polymer Material	5,120,369	Hazardous Material Removal Using Strippable Coatings	Boats - removing contaminants from water exposed surfaces
Radar Simulated targets Artificial Targets	5,138,325	Shipboard Sensor Exerciser Apparatus	Radar training
Microwave Radiation	5,142,250	High Power Microwave Generator	Microwave generators
Ballistic Protection; Body Armor	5,060,314	Multi-mission Ballistic Resistant Jacket	Law enforcement; bullet-resistant protective system
Weather Protective Canopy	5,070,807	Temporary Canopy for Small Water Craft	Lightweight, removable weather protective shield for small, open boats
Electronics	NC# 74,891	Level Gate Board	Electronic gate circuit to control audio signal throughput
Engines	NC# 74,916	Submersible Outboard Engine	Marine environment

**APPENDIX C**

**NSWCDD FY92 TECHNOLOGY APPLICATION ASSESSMENTS**



NSWCDD/MP-93/224

Title	ID No.
Heat Sink Device	NSWCDD-TAA-92-001
Transition Radiation Interference Spectrometer	NSWCDD-TAA-92-002
A Pure-Cartesian Tracking Filter	NSWCDD-TAA-92-003
Hot Water Storage Tank	NSWCDD-TAA-92-004
Detection Circuit for Fiber-Optics Testing	NSWCDD-TAA-92-005
Toroidal Computer Memory	NSWCDD-TAA-92-006
Computer Interface for Operating a Remotely Piloted Vehicle (RPV)	NSWCDD-TAA-92-007

# TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory NSWC, DAHLGREN DIVISION
2. Contact (ORTA) RAMSEY D. JOHNSON (Code D4T)  
Phone (301) 394-1505 DSN 290-1505
3. Address SILVER SPRING, MD 20903-5640
4. Technology Name HEAT SINK DEVICE
5. Technology Type: (a) Process ☒ (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: ☒ (a) Federal Government (b) State Government  
(c) Local Government ☒ (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry (g) Consultant (h) Other: \_\_\_\_\_

A. Date:	<u>16 JANUARY 1992</u>
B. CUFT #:	_____
C. ID #:	<u>NSWCDD-TAA-92-001</u>
D. Descriptors:	
	<u>Heat Sink</u>
	<u>Cylindrical Packaging of Electronics</u>
	_____
	_____
E. Applications:	
	<u>Cooling of high density cylindrically packaged</u>
	<u>electronics via thermal conduction. Applicable</u>
	<u>to test instrumentation such as for oil well</u>
	<u>down-hole equipment and aerospace configur-</u>
	<u>ations having tightly packed components, as</u>
	<u>well as buoys, mines, and missiles.</u>

7. Potential Support: exclusive license, consulting joint venture, drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_
8. What Problem Does It Solve and How? Dissipates heat from electronics components encased in cylindrical housings. The device consists of a heat transfer disk (mounted to the heat generating component) and a heat transfer ring that form a conduction path from the heat source to the external skin of the housing. Applicable to densely packed electronic assemblies in cylindrical casings lacking air space and flow for convection cooling.
9. Other Uses: None
10. Main Advantages: Inexpensive technique for passively cooling cylindrically encased electronic components. Allows for easy installation and removal from cylindrical cases.
11. Production Information: N/A
12. Descriptive Literature: Patent # 5,060,115, "Heat Sink Device for Electronics Modules Packaged in Cylindrical Casings."
- 13a. Literature Available From: Mark W. Sewell, Code F22, (703) 663-7543  
Naval Surface Warfare Center  
Dahlgren Division  
Dahlgren, VA 22448-5000

**13b. Description:**

A heat transfer device invented at the Naval Surface Warfare Center passively cools electronics densely packaged in cylindrical housings. Typical heat transfer devices are designed for conventionally packaged electronics and are not adaptable to high-density configuration lacking air space and flow for internal cooling. It could have applications in the oil industry for cooling electronics in down-hole instrumentation. This new device is specifically useful in cylindrical electronics assemblies of buoys, sonobuoys, torpedoes, and missiles, although it applies to similar configurations in the commercial aerospace industry.

In reference to Figure 1, the device basically consists of a heat dissipating ring (A) that engages the inner surface of the cylindrical case (B). The ring is tapered to receive a heat transfer disk (C). These components form a thermal union with the heat generating module (D) by means of cover plate (E) and fasteners (F).

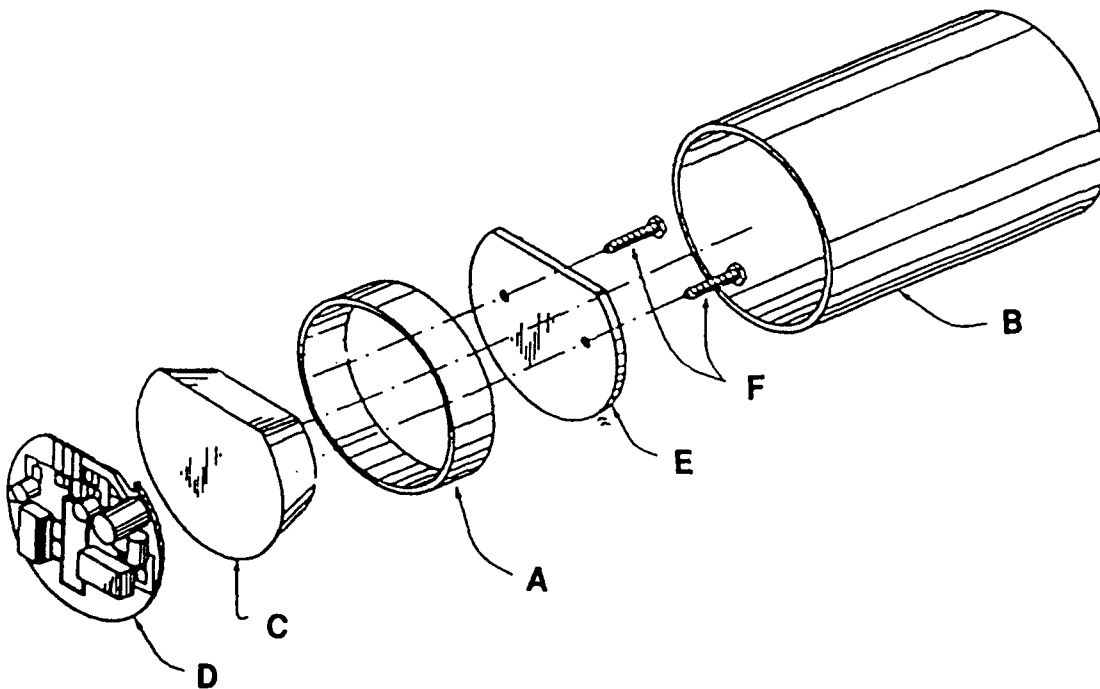


FIGURE 1. HEAT SINK SCHEMATIC

# TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory NSWC, DAHLGREN DIVISION
2. Contact (ORTA) RAMSEY D. JOHNSON (Code D4T)  
Phone (301) 394-1505 DSN 290-1505
3. Address SILVER SPRING, MD 20903-5640
4. Technology Name TRANSITION RADIATION  
INTERFERENCE SPECTROMETER
5. Technology Type: (a) Process ☒ (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: ☒ (a) Federal Government (b) State Government  
(c) Local Government (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry (g) Consultant (h) Other: \_\_\_\_\_

- A. Date: 12 MARCH 1992
- B. CUFT #: \_\_\_\_\_
- C. ID #: NSWCDD-TAA-92-002
- D. Descriptors:  
Beam Quality  
Energy Measurement  
Divergence Measurement  
Charged Particle Beams
- E. Applications:  
Real-time, high resolution measurements of  
charged particle beam parameters: energy;  
divergence; and current density profile.  
Provides fast response time, and measurement  
positions may vary along the beam line.

7. Potential Support: exclusive license consulting joint venture, drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_

8. What Problem Does It Solve and How? Real-time measurement of charged particle beam energy,  
divergence, and current density profile by means of a transition radiation interference spectrometer.

9. Other Uses: N/A

10. Main Advantages: Real-time beam quality measurements of a charged particle beam at many positions  
along the beam path.

11. Production Information: N/A

12. Descriptive Literature: U.S. Patent # 5,045,695 and four related papers.

- 13a. Literature Available From: Ramsey D. Johnson, Code D4T, (301) 394-1505  
Naval Surface Warfare Center, Dahlgren Division  
10901 New Hampshire Avenue  
Silver Spring, MD 20903-5640

## 13b. Description:

NSWCDD has patented an instrument for precision, time-resolved measurements of high energy charged particle beams. This device, the Transition Radiation Interference Spectrometer (TRIS), was developed to provide real-time measurements of key beam parameters which determine the power output of free electron lasers, as well as the beam transport in accelerators. The design of the instrument enables real-time measurements of electron beam energy, divergence, and current density profile. TRIS is specifically designed to measure beam divergences on the order of a few tens of micro-radians during a single beam pulse.

Figure 1 illustrates schematically the components and function of the TRIS system. This is one of a family of beam diagnostics, developed at NSWCDD, which are all based on the unique properties of transition radiation (TR). This radiation is produced when a charged particle beam crosses an interface between vacuum and a dielectric or metallic foil. TR is highly directed, polarized radiation spanning the spectrum from microwaves to X-rays. TRIS and related diagnostic devices are based on the fact that the charged particle beam's properties influence the visible TR's spacial and angular distributions, polarization, and spectral characteristics.

NSWCDD has developed other TR based diagnostic systems to measure electron beam parameters over a wide range of energies and divergences. These are applicable to accelerator development and to precision monitoring of electron beams used for the production of radiation for materials testing and medical applications. Principle features of the device are: real-time energy and divergence measurements, measurement position may vary along the beam line, fast response time, and good spacial resolution.

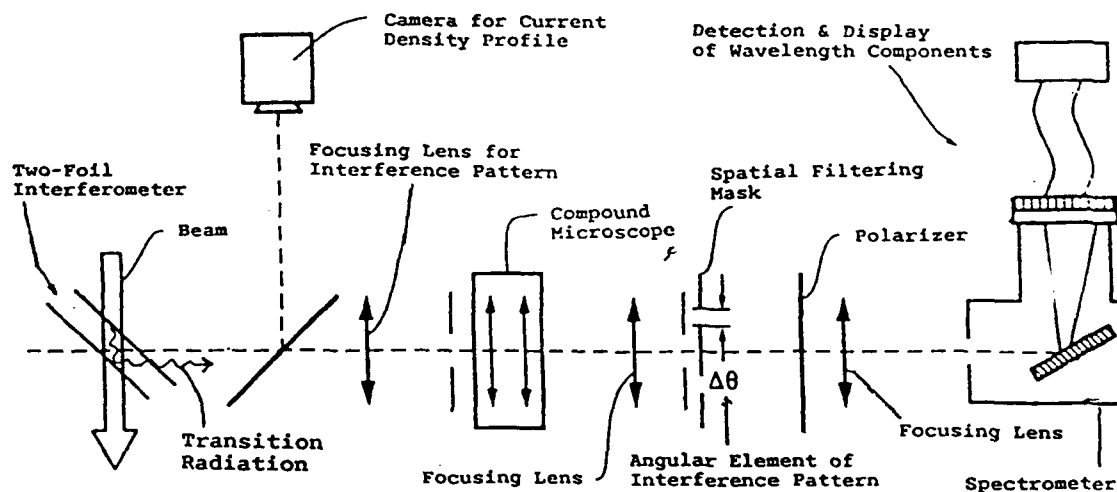


FIGURE 1. TRIS

# TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory NSWC, DAHLGREN DIVISION
2. Contact (ORTA) RAMSEY D. JOHNSON (Code D4T)  
Phone (301) 394-1505 DSN 290-1505
3. Address SILVER SPRING, MD 20903-5640
4. Technology Name A PURE-CARTESIAN TRACKING FILTER
5. Technology Type: ☒ (a) Process (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: ☒ (a) Federal Government (b) State Government  
☒ (c) Local Government ☒ (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry ☒ (g) Consultant (h) Other: \_\_\_\_\_

A. Date:	<u>27 APRIL 1992</u>
B. CUFT #:	_____
C. ID #:	<u>NSWCDD-TAA-92-003</u>
D. Descriptors:	<u>Tracking Filter</u> <u>Kalman Filter</u>
E. Applications:	<u>Kalman filter tracks objects using measurements from a sensor that only measures object direction (e.g., optical sensor), or a sensor that measures range (radar systems). Can be applied to a broad range of tasks, such as to: determine the position and velocity of an airplane; guide an intercept object to a target, support robotic vision, support multisensor tracking of an object; simulate scenarios (e.g., outfielder judging a fly ball); or support a variety of other tasks in which precise knowledge of the position and velocity of a tracked object is required.</u>

7. Potential Support: exclusive license, consulting, joint venture drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_

8. What Problem Does It Solve and How? The invention is a Kalman filter that tracks objects, such as airplanes or missiles. The filter can use measurements from a sensor that only measures target direction, such as an optical sensor, or a sensor that also measures range, such as a radar system. The filter can also be used for multisensor tracking.

The key to the filter is its measurement expression. In conventional angle-only filters, the sensor measurements are expressed in terms of elevation and bearing to the target; i.e., in a spherical coordinate system. The proposed tracking filter uses a different approach. Each time step, the filter constructs a Cartesian frame, referred to as the target line-of-sight frame, with origin at the sensor and one axis along the instantaneous expected line of sight to the target. The sensor measurements, expressed in vector form, are then transformed into this frame, and the components of the resulting vector, not the original sensor measurements, are used as inputs to the tracking filter. The technique results in a statistically-uncorrelated Cartesian expression of the sensor measurements.

9. Other Uses: N/A

10. Main Advantages: (a) The filter is strictly Cartesian. Every aspect of the filter - from the expression of the sensor measurements to the filter's state vector - is defined in Cartesian frames. Consequently, the filter is less non-linear than conventional filters and, unlike filters that use elevation and bearing measurements, does not have a singularity along the polar axis.

(b) The filter is flexible and can be applied to virtually any tracking problem. The filter can use measurements from an angle-only sensor (a sensor that only measures direction to the target, such as an optical sensor) or an angle-plus-range sensor. It can use measurements from moving or rotating sensors, or even multiple sensors handle. It can also handle relatively difficult tracking problems, such as range estimation (via geometric triangulation) using measurements from an angle-only sensor.

10. Main Advantages: The filter is efficient. Because the filter is strictly Cartesian, it avoids the use of trigonometric functions.

11. Production Information: The tracking filter is a sophisticated mathematical algorithm. Since the filter must be tailored to the requirements of each application, the filter software should be formulated by someone experienced in Kalman filter design.

12. Descriptive Literature: (a) R. L. Gray, "A Method of Kalman Filtering for Estimating the Position and Velocity of a Tracked Object," U.S. Patent No. 5,051,751, Sep 1991.

(b) R. L. Gray, "Pure-Cartesian Formulation for Angle-Only and Angle-plus-Range Tracking Filters," SPIE Acquisition, Tracking, and Pointing VI Conf., Orlando, FL, Apr 1992.

13a. Literature Available From: Mr. Ramsey D. Johnson, Code D4T, (301) 394-1505  
Naval Surface Warfare Center, Dahlgren Division  
10901 New Hampshire Avenue  
Silver Spring, MD 20903-5640

Mr. Roger L. Gray, Code K41, (703) 663-8867  
Naval Surface Warfare Center  
Dahlgren Division  
Dahlgren, VA 22448-5000

**13b. Description:**

The invention is a Kalman filter that tracks objects, such as airplanes or missiles. The filter can use measurements from a sensor that only measures target direction, such as an optical sensor, or a sensor that also measures range, such as a radar system. The filter can also be used for multisensor tracking.

**Advantages over present methods:**

(a) **The filter is strictly Cartesian.** Every aspect of the filter – from the expression of the sensor measurements to the filter's state vector – is defined in Cartesian frames. Consequently, the filter is less nonlinear than conventional filters and, unlike filters that use elevation and bearing measurements, does not have a singularity along the polar axis.

(b) **The filter is flexible and can be applied to virtually any tracking problem.** The filter can use measurements from an angle-only sensor (a sensor that only measures direction to the target, such as an optical sensor) or an angle-plus-range sensor. It can use measurements from moving or rotating sensors, or even multiple sensors. It can also handle relatively difficult tracking problems, such as range estimation (via geometric triangulation) using measurements from an angle-only sensor.

(c) **The filter is efficient.** Because the filter is strictly Cartesian, it avoids the use of trigonometric functions.

**Applications:** The filter can be applied to a broad range of tasks. The method can be used to determine the position and velocity of an airplane using radar measurements, guide an intercept vehicle to a target, support robotic vision, support multisensor tracking of an object, simulate an outfielder judging a fly ball, or support a variety of other tasks in which precise knowledge of the position and velocity of a tracked object is required.

**Stage of development:**

(a) The filter has been tested in a computer simulation of a satellite interception. Using measurements from an ill vehicle's sensor, the filter accurately estimated the position and velocity of a satellite – the statistical performance predicted by the filter covariance matrix was consistent with the results of Monte Carlo study. (R. L. Gray, *Terminal Guidance Technique for a Kinetic Kill Vehicle that uses Solid-Fuel Divert Motors*, NAVSWC TR 90-237, Mar 1991.)

(b) The filter's capability for range estimation using measurements from an angle-only filter has also been demonstrated via computer simulation. (R. L. Gray, "Pure-Cartesian Formulation for Angle-Only and Angle-plus-Range Tracking Filters," SPIE Acquisition Tracking, & Pointing VI Conf., Orlando, FL, Apr 1992.)

U.S. Patent No. 5,051,751; R. L. Gray, "A Method of Kalman Filtering for Estimating the Position and Velocity of a Tracked Object."



# TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory NSWC, DAHLGREN DIVISION
2. Contact (ORTA) RAMSEY D. JOHNSON (Code D4T)  
Phone (301) 394-1505 DSN 290-1505
3. Address SILVER SPRING, MD 20903-5640
4. Technology Name HOT WATER STORAGE TANK
5. Technology Type: (a) Process ☒ (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: ☒ (a) Federal Government ☒ (b) State Government  
☒ (c) Local Government ☒ (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry (g) Consultant ☒ (h) Other: Private  
and commercial hot water tank users.

- |   |
|---|
| A. Date: <u>19 MAY 1992</u>   |
| B. CUFT #: _____  |
| C. ID #: <u>NSWCDD-TAA-92-004</u>   |
| D. Descriptors:<br><u>Hot water tank</u><br><u>Solar heating system</u><br><u>Hot water storage efficiency</u>  |
| E. Applications:<br><u>Residential and commercial hot water storage</u><br><u>systems having nonintegral heating sources -</u><br><u>such as solar heating or recovered heat from</u><br><u>motors and other heat generating devices.</u> |

7. Potential Support: exclusive license, consulting, joint venture, drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_
8. What Problem Does It Solve and How? Provides more efficient method for hot water storage by reducing radiant heat loss and by advantageous positioning of inlet/outlet pipes to more effectively use tank temperature gradients. Any source of heat may be used with this tank, such as solar heating devices and waste heat from air conditioning and refrigeration units.
9. Other Uses: N/A
10. Main Advantages: Improved hot water storage efficiency, no restrictions on heat source, passive operation, low technical investment and risk.
11. Production Information: Easily manufactures, requires low technical skills for fabrication, comprised of existing materials and components.
12. Descriptive Literature: U.S. Patent No. 5,159,918
- 13a. Literature Available From: Ramsey D. Johnson, Code D4T, (301) 394-1505  
Naval Surface Warfare Center, Dahlgren Division  
10901 New Hampshire Avenue  
Silver Spring, MD 20903-5640

**13b. Description:**

A more energy efficient hot water storage tank for solar collectors has been invented at NSWCDD. Analysis shows a relative radiant heat loss reduction of about 40 percent for the improved tank versus a conventional hot water tank under similar condition. The principal features of the tank are: (a) a method to provide a vertical temperature gradient within the tank that provides a lower temperature water supply for a solar collector and (b) a method for attaining a radial temperature gradient within the tank to reduce radiated heat loss.

Improved efficiency is achieved by a concentric baffle arrangement in the hot water tank along with circulation ports at top and bottom of the baffle. This configuration restricts the mixing of water and allows two temperature gradients – one lateral across the tank and the other vertical within the tank. Thus radiant heat losses are significantly reduced, and the coldest water is always directed to the solar panels while the hottest is directed to the hot water supply pipe. The temperature gradient within the tank maintains hot water in the inner core with slightly cooler water surrounding the core. Thus, radiant heat losses from the inner volume are reduced because of: (a) a smaller temperature difference between the inner volume and outer annular volume and (b) heat loss from the outer volume is lower due to its lower temperature. The vertical temperature gradient allows increased efficiency of the solar panels because the coldest available water is directed to them.

**Novel features:**

(a) Interior baffle and port arrangements to achieve lateral and vertical temperature gradients that reduce heat losses and improve water heating efficiency.

(b) The improved tank is not restricted to use with solar panels; any heat source may be used (e.g., waste heat from air conditioning or refrigeration units),

(c) The tank may be an oval shape (versus cylindrical) to accommodate space and handling requirements.

# TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory NSWC, DAHLGREN DIVISION
2. Contact (ORTA) RAMSEY D. JOHNSON (Code D4T)  
Phone (301) 394-1505 DSN 290-1505
3. Address SILVER SPRING, MD 20903-5640
4. Technology Name DETECTION CIRCUIT FOR  
FIBER-OPTICS TESTING
5. Technology Type: (a) Process ☒ (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: ☒ (a) Federal Government (b) State Government  
(c) Local Government (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry (g) Consultant (h) Other: \_\_\_\_\_

A. Date:	<u>19 JUNE 1992</u>
B. CUFT #:	_____
C. ID #:	<u>NSWCDD-TAA-92-005</u>
D. Descriptors:	_____
	<u>Fiber-optics testing</u>
	<u>Optical detection</u>
	_____
	_____
E. Applications:	_____
	<u>Shock and vibration performance testing of</u>
	<u>fiber-optic components (connectors, optical</u>
	<u>switches, rotary splices, and junction boxes)</u>
	<u>used in rigorous conditions aboard ships,</u>
	<u>aircraft, spacecraft, and similar environments.</u>

7. Potential Support: exclusive license, consulting, joint venture, drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_
8. What Problem Does It Solve and How? This opto-electronic circuit – featuring precision high bandwidth, low noise, low drift, low power consumption – is now used for measuring the change in optical power during shock and mechanical vibration testing of naval shipboard fiber-optic components such as connectors, optical switches, rotary splices, and junction boxes. It is also applicable to testing components prior to their installation in similar mechanically stressful situations.
9. Other Uses: Air shock testing from explosive sources.
10. Main Advantages: High bandwidth (> 100 KHz), low noise, low drift, low electrical power consumption, only three components.
11. Production Information: Three principal components are commercially available, off-the-shelf items.
12. Descriptive Literature: (a) Technical Article, "Design of a Ten Channel High Bandwidth, High Output, Low Noise Optical Detection Circuit."  
(b) U.S. Patent Application (Navy Case # 74156), "Fiber-Optic Testing System Having a Detection Circuit."
- 13a. Literature Available From: Ramsey D. Johnson, Code D4T, (301) 394-1505  
Naval Surface Warfare Center, Dahlgren Division  
10901 New Hampshire Avenue  
Silver Spring, MD 20903-5640

**13b. Description:**

Fiber-optic components employed in shipboard, aircraft, and a spacecraft applications are subjected to rigorous shock and vibration conditions that can significantly degrade performance of associated systems. NSWCDD has invented a detection circuit for a fiber-optic testing system that results in an improved diagnostic tool for developing more ruggedized fiber-optic components such as connectors, optical switches, rotary splices, and junction boxes. This optical-to-electrical circuit features a precision high bandwidth, low noise, low drift, and low power consumption.

The testing system monitors optical performance changes during shock and vibration conditions allowing designers to identify and correct operational deficiencies prior to final assembly and installation. As shown schematically in Figure 1, the testing system consists of an infrared radiation source (1300 nm wavelength), an optic coupler, a detecting circuit, and a recording instrument. The system's low noise, large bandwidth optical-to-electrical detection circuit has the following features:

- a. Frequency response: DC to >100 KHz
- b. Voltage output: 0.5 VDC analog with a 1 Microwatt optical input
- c. Signal-to-noise ratio less than 1 percent
- d. DC stability less than 1 mv drift in 24 hours.

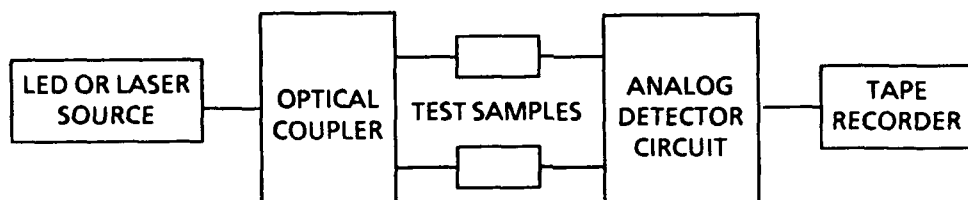


FIGURE 1. FIBER-OPTIC TESTING SYSTEM SCHEMATIC

# TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory NSWC, DAHLGREN DIVISION
2. Contact (ORTA) RAMSEY D. JOHNSON (Code D4T)  
Phone (301) 394-1505 DSN 290-1505
3. Address SILVER SPRING, MD 20903-5640
4. Technology Name TOROIDAL COMPUTER MEMORY
5. Technology Type: ☒ (a) Process ☒ (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: Software
6. Users: ☒ (a) Federal Government (b) State Government  
(c) Local Government ☒ (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry (g) Consultant (h) Other: \_\_\_\_\_

A. Date: <u>30 JUNE 1992</u>
B. CUFT #: _____
C. ID #: <u>NSWCDD-TAA-92-006</u>
D. Descriptors: <u>Toroidal computer memory</u> <u>Memory paths</u>
E. Applications: <u>General processing</u> <u>Subword level processing</u> <u>Bit level processing</u>

7. Potential Support: exclusive license, consulting, joint venture, drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_

8. What Problem Does It Solve and How? Conventional computer memory is structurally linear and its access can only occur in a "linear" manner. Such memory has certain efficiency limitations when dealing with such applications as bit level processing requiring certain bit orders in the retrieved data in that software must be used to manipulate data outside memory to place it in proper form for processing. Toroidal memory can alleviate certain of these problems by providing a storage/retrieval media which can efficiently service associated computational processes with memory paths of data that can be obtained in a single access, or fewer accesses, then are required via conventional computer memory.

9. Other Uses: General processing (the memory can be configured to be conventional), subword level processing, bit level processing, processing requiring special data orderings that can be retrieved in a single access.

10. Main Advantages: Enhanced performance for certain applications by removing software complexity.

11. Production Information: Although specialized high technology devices may be used to construct these systems, they may be inexpensively fabricated from off-the-shelf RAM devices and moderate to low technology fabrication techniques.

12. Descriptive Literature: Parks, A. D.; Perry, J. C.; and Shuler, A. P., "M-Dimensional and Toroidal Computer Memories," Proceedings of the 2nd Navy Independent Research/Independent Exploratory Development Symposium, Naval Surface Warfare Center, Silver Spring, MD, 6-7 Jun 1989, Vol. 1, pp 177-189, Chemical Propulsion Information Agency, The Johns Hopkins University, Applied Physics Laboratory, Laurel, MD 20707-6099.

13a. Literature Available From: Dr. A. D. Parks, Code K13, (703) 663-8872  
Dr. J. C. Perry, Code K12, (703) 663-7133  
Naval Surface Warfare Center  
Dahlgren Division  
Dahlgren, VA 22448-5000

## 13b. Description:

(A) Abstract Characterization. Let each memory word correspond to a tuple in the set  $M = N_1 \times N_2$ , where  $N_i = \{0, 1, 2, \dots, n_i\}$ ,  $i = 1, 2$ , and  $T$  be a torus obtained by identifying the opposite edges of the rectangle  $R = \{(x, y) \in \mathbb{R}^2 | 0 \leq x \leq n_1 + 1, 0 \leq y \leq n_2 + 1\}$ . If  $\Psi = \Psi_2 \circ \Psi_1$ , where  $\Psi_1: M \rightarrow R$  is an imbedding such that  $(i, j) \rightarrow (i, j)$  and  $\Psi_2: R \rightarrow T$  is the identification map, then we define the associated toroidal memory to be the triple  $(M, R, \Psi)$ . Thus, each memory word in  $M$  is associated with a point on the surface of  $T$ .

A toroidal path is a simple, not necessarily closed, curve on  $T$  which originates at the origin of  $R$ . A toroidal memory with path accessibility is one in which certain paths contain required collection of retrievable/updatable memory words as subsets. Such collections will be called memory paths. If  $m/n$ , where  $0 \leq m \leq n_2$  and  $0 \leq n \leq n_1$ , is the slope of a toroidal path in  $R$  which contains a memory path, then we shall denote it and its associated memory path by  $K_{m,n}$  and  $P_{m,n}$ , respectively.

(B) Path Properties in  $(M, R, \Psi)$ . We present the following theorems which describe the key features of  $P_{m,n}$ 's which are accessible in  $(M, R, \Psi)$  and are of primary importance to the design of a toroidal memory system. Let  $(\alpha, \beta)$  denote the greatest common divisor of  $\alpha$  and  $\beta$ ,  $X$  denote the set of all  $x$  coordinates in  $P_{m,n}$ ,  $k$  be a nonnegative integer, and  $r = n_i + 1$ ,  $i = 1, 2$ .

Theorem 1.  $P_{m,n} = \{(\text{mod}(kn, n'_1), \text{mod}(km, n'_2)) | 0 \leq k \leq k_{\max}\}$

Theorem 2. If  $(n'_1, n) = 1$  and  $k_{\max} \geq n_1$ , then  $X = N_1$

Theorem 3. Let  $(n'_1, n'_2) = r$ , where  $n'_1 = ar$ ,  $n'_2 = br$ ,  $(b, m) = q$ , and  $b = cq$ . If  $(n'_1, n) = 1$ , then  $K_{m,n}$  is closed for  $k_{\max} = (cn'_1 - 1)$

It is important to not here for design purposes, that if  $n'_1 = n'_2$  is chosen to be a prime number, then  $(n'_1, n) = 1$  for all  $n \leq n_1$ ,  $c = 1$ , and  $k_{\max} = n_1$ .

(C) Physical Realizations Using Random Access Memory (RAM). Here we use the RAM chip as the basic building block for this electronic memory system.

The approach taken for this memory system is to use  $n_1 + 1$  groups of  $\lambda$  independently addressable RAM circuits of depth,  $n_2 + 1$ , where RAM group ID  $\in N_1$  and RAM address  $\in N_2$ , so that (RAM group ID, RAM address)  $\in M$ . The associated  $(M, R, \Psi)$  with memory path access can be obtained by identifying the opposite edges of  $R = \{(x, y) \in \mathbb{R}^2 | 0 \leq x \leq n_1 + 1, 0 \leq y \leq n_2\}$  using Theorem 1 as a RAM group ID and address control function; i.e., for a given  $k$  and  $P_{m,n}$ , the RAM group ID =  $\text{mod}(kn, n'_1)$  and the RAM address =  $\text{mod}(km, n'_2)$ . Here the rule RAM identifier =  $\lambda \cdot \text{RAM group ID} + (J - 1)$ , where  $1 \leq J \leq \lambda$  is used to control the addressing within a group and ensures that identical addresses are received by each RAM circuit within the group.

# TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory NSWC, DAHLGREN DIVISION
2. Contact (ORTA) RAMSEY D. JOHNSON (Code D4T)  
Phone (301) 394-1505 DSN 290-1505
3. Address SILVER SPRING, MD 20903-5640
4. Technology Name COMPUTER INTERFACE FOR OPERATING  
A REMOTELY PILOTED VEHICLE (RPV)
5. Technology Type: (a) Process (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: (a) Federal Government (b) State Government  
(c) Local Government (d) Small Industry (e) Medium Industry  
(f) Large Industry (g) Consultant (h) Other: \_\_\_\_\_

- |   |
|---|
| A. Date: <u>30 SEPTEMBER 1992</u>                       |
| B. CUFT #: _____  |
| C. ID #: <u>NSWCDD-TAA-92-007</u>                       |
| D. Descriptors:   |
| <u>RPV</u>  |
| <u>Remote control</u>                                   |
| <u>Computer control</u>                                 |
| <u>Automation</u>                                       |
| <u>Robotics</u>   |
| E. Applications:  |
| <u>Provides computer controlled operation of a</u>      |
| <u>remotely piloted vehicle. Control can be precise</u> |
| <u>and optionally preprogrammed using this</u>          |
| <u>RPV interface.</u>                                   |

7. Potential Support: exclusive license consulting joint venture, drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_

8. What Problem Does It Solve and How? The RPV Computerized Transmitter Interface provides the capability to control any remotely piloted vehicle such as radio controlled airplanes, drones, boats, cars, and hovercrafts via a computer. The computer can provide precise control and preprogrammed routing of the RPV for military target practice or commercial entertainment. An RPV which is fitted with a camera can provide commercial land surveying and military/law enforcement intelligence.

9. Other Uses: An RPV may be controlled via a network of computers. When fitted to robotics, it can be used to guide a robot in traversing terrain or simple movements.

10. Main Advantages: More precise control of RPV movements. RPV can be placed on "auto-pilot."

11. Production Information: All components to build the interface are commercially available. The Government can provide the firmware which runs the interface. Software for the host computer must be developed by the licensee.

12. Descriptive Literature: (a) Technical Paper - NAVSWC TN 91-601, Computer Interface for Operating a remotely Piloted Vehicle.  
(b) U.S. Patent Application (Navy Case #74060) - "Remotely Piloted Vehicle Control and Interface System."

- 13a. Literature Available From: Ramsey D. Johnson, Code D4T, (301) 394-1505  
Naval Surface Warfare Center, Dahlgren Division  
10901 New Hampshire Avenue  
Silver Spring, MD 20903-5640

**13b. Description:**

A computer-based control and interface system has been developed for precision control of remotely piloted vehicles (RPVs). This digital control system replaces the traditional analog joystick control movements that are transmitted to RPVs via a radio frequency (RF) link. Precision control of RPV movements is difficult to achieve with a joystick, whereas this new control system provides precision commands generated from a personal computer interface to more accurately operate the vehicle within desired speed and direction parameters.

Flight control parameters entered via keyboard are converted by the computer into a serial data stream of ASCII characters. A shift register converts this serial data to a parallel data character and continuously generates a status signal indicating a presence or absence of the parallel data character. A central processing unit, responsive to the status signal, compares the parallel data character with a set of valid control characters. A control signal is generated when the parallel data character matches one character from the set of valid control characters. This control signal is issued to a standard RF transmitter normally used in the joystick/transmitter configuration of an RPV, thus no modifications to the RPV are required.

This control technique is readily applicable to recreational, commercial, and military uses, ranging from toys to complex RC drones used in experimental or military roles.

**Advantages:**

- a. Provides a control system that eliminates human joystick controller error.
- b. Provides a precise, digital control to more accurately operate RPVs within scaled speeds and/or directions.
- c. Offers autonomous robotic RPV operation under computer control.
- d. Requires no modifications to existing RPV receiver and control mechanisms.
- e. Adapts to a variety of RPV types.

**For licensing information contact:**

Mr. Jacob Shuster, Code C72W, (301) 394-2171  
Assistant Counsel for Intellectual Property  
Naval Surface Warfare Center, Dahlgren Division  
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Silver Spring, MD 20903-5640



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ATTN DR O LOMACKY	1	CHIEF SCIENTIST AFSC	
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